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OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Committee on Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Franklin Institute.

HALL OF THE INSTITUTE, March 21st, 1877.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 119 members and 12 visitors.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were presented, showing that at its last meeting 19 persons were elected members of the Institute and the following donations made to the library:

Specifications and drawings of Patents for September, 1876. From the U. S. Patent Office.

Annual report of the St. Louis Mercantile Library Association. 1876. From the Association.

Report of the Western Railroad Association for 1876. From the Association.

New Encyclopædia of Chemistry. Pts. 15—20. From J. B. Lippincott & Co., Publishers, Philad'a.

Index to the catalogue of the ordnance collection. Washington, 1876.

Military Bridge equipage, designed and constructed by V. Norrman. Philad'a, 1876.

Swiss catalogue of the International Exhibition in Philadelphia, 1876.

Swedish catalogue: 1, Statistics; 2, Exhibits, International Exhibition, 1876, Philadelphia.

The exhibition of the Geological survey of Sweden at the exhibition at Philadelphia, 1876.

Surahammars Bruks Aktiebolay Sverige. Stockholm, 1876.

Mechanico therapeutic institution in Stockholm, by G. Zander. Philad'a, 1876.

Description of hydrographical and meteorological instruments exhibited at the Philadelphia Exhibition, Philad'a, 1876. Stockholm.

On the state of the Iron manufacture in Sweden at the beginning of 1876, by R. Ackerman. Stockholm, 1876.

Synopsis of the Christian Hammer's Museum of Art and Antiquity. Stockholm. From the Swedish Commission.

Catalogue of Canadian exhibitors at the International Exhibition, Philad'a. Montreal, 1876.

Manitoba and the North West of the Dominion, its resources and advantages, by T. Spence.

Dominion of Canada, Province of Ontario. Catalogue of exhibits in Education department, Centennial Exhibition, Philad'a. Toronto, 1876. From the Canadian Commission.

Woods and minerals of New Brunswick. Descriptive catalogue prepared for Centennial Exhibition, Philad'a, 1876. Frederickton, N. B., 1876.

Memoir on the novel formation of the bottom of ships and vessels, proposed by the Brazilian naval architect, Trajano A. de Carvalho. Philad'a, 1876.

Brazilian section, Machinery Hall. Notice on the models of ships, exhibited by the Rio de Janeiro Navy Yard, Philad'a International Exhibition, Philad'a, 1876.

Catalogue of the Russian section, International Exhibition of 1876, at Philadelphia. St. Petersburg, 1876.

Description of the collections of Scientific appliances instituted for the study of mechanical art in the workshops of the imperial technical school of Moscow. 1876.

From the Russian Commission.

International Exhibition, 1876. Official Catalogue, Main Building, Pts. 1 and 2. Philad'a, 1876.

Corporation, "The Artisan's school, Rotterdam, Holland, established in 1869."

German department. Official Catalogue. Berlin, 1876.

Bessemer steel, exhibited by Fagersta Bruk, at the Intern. Exhibition, Philad'a, 1876.

International-Ausstellung in Philadelphia, 1876. Das Unterrichts-schul- und Bildungswesen der Schweizerischen Abtheilung. St. Gallen, 1876. From the German Commission.

Special Catalogue of the Netherlands section, edited by authority of the Royal Commission of the Netherlands, International Exhibition, Philad'a, 1876.

Kirkaldy's experimental inquiry into the mechanical properties of Fagersta steel. London, 1876.

Second preliminary report on the mineralogy of Pennsylvania, by F. A. Genth, with analyses of mineral spring waters. From F. A. Genth.

Columbia College School of Mines, Catalogue of the officers and students, for the year 1876-7. From the College.

Illustrated catalogue and manual, improved engineering instruments. From Buff & Berger, makers.

Annual report of the Chief of Engineers to the Secretary of War, for the year 1876. In 3 parts. From the Chief of Engineers.

Annual report of the Board of Directors of the Pennsylvania Institution for the Deaf and Dumb, for the year 1876. From Wm. Welsh.

Proceedings and Transactions of the Nova Scotian Institute of Natural Science, of Halifax, Nova Scotia. Vol. 4. 1875–76. Pt. 2. From the Institute.

Annual report of the Secretary of the Treasury on the state of the finances, for the year 1876. From the Treasury Department.

British patent specifications issued from August 5th to December 30th, 1876. British patent abridgments on artificial leather, 1627-1866. Wearing apparel. Div. 4. Dress fastenings and Jewelry, 1631-1866. Agriculture. Div. 1. Field implements, 1618-1866. Trunks, portmanteaus, etc. 1835-1866. Victoria patents and patentees. Vol. 8. Indexes for the year 1873, by Richard Gibbs, Registrar General. From the Patent Office.

Annual reports of the operations of the U. S. Life Saving Service, for the fiscal year ending June 30, 1876. From the Treasury Department.

Silk industry in America. A history prepared for the Centennial Exhibition, by L. P. Brockett, 1876. From F. O. Horstmann.

Report on the salt manufacture of Michigan, by S. S. Garrigues. State salt insp. N. Y., 1876. From the author.

An essay on New South Wales, by G. H. Reid. Sydney, 1876.

Three papers on heat and combustion, read before the Railway Polytechnic Society of Cleveland, Ohio, by P. H. Dudley, C. E. From the author.

Ritchie's catalogue of philosophical apparatus. Boston, 1875. From E. S. Ritchie & Sons.

American Journal of Microscopy and popular science. Vol. 1. N. Y., 1876. From the editor.

The Committee on Primary Industrial Education presented a partial report which was read,[1] and was followed by an animated discussion by a considerable number of members, when on motion of Mr. Whitney, it was

Resolved, That the chairman of the committee be authorized to have printed not more than 1200 copies of the report, and that one be sent to each member of the Board of Education.

Mr. R. Bingham, of Camden, was then introduced, and read the paper announced for the evening, on Useful Education.

The Secretary presented his report, embracing Edgerton's self-condensing Gasholders, with safety arrangement; Zuccato's Papyrograph for printing autograph letters or circulars; the Fowler Fly fan; the Cascade Evaporator for hot air registers; John McConn's rock expansion joint, and some new experiments with a modified Atwood falling machine by Mr. J. W. Nystrom.

Mr. J. J. Weaver offered the following preamble and resolutions, which, on motion of Mr. Cartwright, were postponed to the next meeting:

WHEREAS, Whatever tends to improve the condition of the skilled mechanic, and aids in bringing him to the notice of those requiring his services when necessary, is clearly within the province of the Franklin Institute, viz.: "The promotion of the mechanic arts," therefore be it

Resolved, That the Secretary be directed to provide a book, in which he shall enter the names, occupations, references, etc., of those members of the Institute who may report themselves to him as being out of, and desiring employment; and that the Secretary shall have printed upon the monthly notices, sent to each and every member of the Institute, the *occupation only* of those who have so reported to him.

Resolved, That those members who may require the services of such, shall be furnished with detailed information only by personal

[1] See page 221.

application to the Secretary; the Secretary to give information touching the special occupation in which the member applying is interested, and none other.

The President announced that he had appointed the following members on the standing committees of the Institute for the current year:

On Library.—Chas. Bullock, Saml. Sartain, W. P. Tatham, Jos. M. Wilson, Pliny E. Chase, Robert Briggs, J. B. Knight, E. J. Houston, J. W. Nystrom, Dr. Isaac Norris, Jr.

On Minerals.—Dr. F. A. Genth, Theo. D. Rand, Clarence Bement, Persifor Frazer, Jr., Dr. W. H. Wahl, E. J. Houston, Otto Luthy, Robert Grimshaw, E. F. Moody, Dr. G. A. Kœnig.

On Meteorology.—Pliny E. Chase, Hector Orr, Dr. Isaac Norris, Jr., John Wise, J. E. Mitchell, Jas. A. Kirkpatrick, David Brooks, Alex. Purves, Dr. W. H. Wahl.

On Models—H. L. Butler, Edward Brown, M. L. Orum, J. Gœhring, L. L. Cheney, J. J. Weaver, C. Chabot, J. B. Knight, S. Lloyd Wiegand, A. G. Busby.

On Arts and Manufactures.—J. J. Weaver, Geo. V. Cresson, Hector Orr, Coleman Sellers, Jr., W. B. LeVan, Wm. Helme, H. W. Bartol, J. S. Bancroft, Alfred Mellor, Cyrus Chambers, Jr.

On Meetings.—H. Cartwright, Saml. Sartain, Washington Jones, J. B. Knight, C. S. Close, P. E. Chase, W. P. Tatham, L. M. Haupt, W. L. Dubois.

On motion, the meeting adjourned.

J. B. KNIGHT, *Secretary.*

REPORT OF COMMITTEE ON PRIMARY INDUSTRIAL EDUCATION.

The Committee of the Franklin Institute appointed to consider certain alleged defects in the education of children in public schools and private seminaries, by which the true dignity of labor is impaired, and there is an absence of special preparation for mechanical and other useful arts, makes the following partial report:

Your Committee, after a personal inspection of public schools and conferences with their teachers, directors, and the Board of Education, has become satisfied that whilst the instruction, in almost all of these schools, is very defective in the particulars referred to, yet there is a general disposition to make the instruction more practical, that the children may be prepared for earning a livelihood by industrial pursuits.

The point to which your Committee has thus far more particularly directed its investigation, is that of "object teaching," which has been followed by very satisfactory results in schools where introduced. The importance of this system is acknowledged by all who have had the opportunity of witnessing a fair trial, and we think it only necessary to bring it fully before those having authority, to secure its enforcement in all the schools of the city.

The old system of instruction is based upon the supposition that mental power can be increased most effectively by memorizing words, and by grappling with abstract ideas. This system is, no doubt, adapted to some mature minds of extraordinary power, and possibly in a very few cases to the young, but not to the many.

The great advantage of object teaching is that it cultivates the perceptive faculties and quickens the observation, leading the mind from the object to its name and uses, which is certainly the natural course of learning. By this means the subject of the lesson is first fixed in the mind, then an interest is developed from a natural curiosity, and finally there grows up a love of study.

On the contrary, under the old system all the child learns is from an effort of the memory only, the abstract names having no association with visible things, and the explanation of their properties and uses being simply so many sentences to be memorized, without any appreciation of their meaning.

Thus, by the objective system, the child not only learns more quickly and thoroughly the lesson given it, but it is also taught how to learn. In fact, what is called objective teaching in the primary schools, is precisely what is done in the higher departments, where the students have illustrated lectures and the use of apparatus for practice in laboratories. All our great institutions of learning spend large sums of money in the purchase of such apparatus, and for no other reason than an appreciation of the immense advantages to be derived from having before the students the object to illustrate the principles being taught.

If so great benefits are derived from this method in the case of advanced students, where the mind has already been trained to some extent to methods of thought, how much more important is it with the child who has still to learn the true use of its perceptive faculties, and needs that development of its reasoning powers which will enable it to grapple with abstract principles. Under any of the

approved systems of object teaching, the happiness and health of the child are better maintained, for much more attention is given to physical exercise, thus leaving it better able to withstand the strain of more advanced studies when reached.

One of the greatest difficulties to be encountered in effecting any change in the system of teaching, must naturally be the want of the necessary training on the part of the teachers, and in order to overcome this difficulty, a school of practice was organized on the first of January last in connection with the Girls' Normal school. This school is organized on exactly the same plan as other public schools: it numbers six primary and four secondary divisions, and is supplied with a complete outfit of material for the most approved system of object teaching. The pupils are instructed by those of the graduating class of the Normal school alternately, under the direction of a principal, elected for that purpose. Here, children from six to seven years old, become practically familiar with weights and measures, and acquire remarkable skill in drawing on the blackboard the sizes and shapes of objects, while describing their nature and uses.

This school of practice will enable a fair comparison to be made between the two systems, as the pupils are drawn from that portion of the city convenient to the school, and from among those who attend the regular primary schools.

Thus the graduates of the Normal school—a large portion of whom are expected to become teachers—will be familiar with the system of object teaching and its advantages, and as the success of any educational system depends largely on the teachers, they cannot fail to have a great influence in improving that of our city.

This school of practice is under the immediate direction of the Board of Education, a majority of which manifest a strong desire to extend the same system of teaching throughout the city. This Board several years since placed object teaching on the schedule of instruction, to be given in all the Public schools of this city. To this time, so far as your Committee has been informed, some of the schools in the Eighth Ward have alone complied with this requirement of the Board of Education. Many members of the Teachers' Association are also anxious to see object teaching, including drawing, and other practical instruction, universally taught. In this respect several of the other large cities are much in advance of Philadelphia, as they have Superintendents and Assistant Superintendents of Public

Instruction, through whose agency these improvements have been made. In Pennsylvania, the instruction outside of Philadelphia is under the direction of J. P. Wickersham, the Superintendent of Public schools, who cordially supports the views of your Committee.

The public schools in Philadelphia, although under the general direction of the Board of Education, are controlled by directors elected in each ward. Your Committee has resolved to convene first the teachers and then the directors in the lecture room of the Franklin Institute, with the hope that a personal conference will influence them to give the children in their respective schools and wards the advantage of a practical preparation for industrial pursuits.

The subject of teaching drawing in the public schools has had as yet but limited consideration, but your Committee is satisfied of its great importance, as preparing the pupil for instruction in every useful art—whether as an apprentice, or as a pupil in some industrial or technical school.

This subject, as well as that of industrial and technical schools, will be considered more fully in a future report.

WM. WELSH, *Chairman.*

Donations continued from March Number.

Report on the transportation route along the Wisconsin and Fox rivers, in the state of Wisconsin, etc., by G. K. Warren. Washington, 1876. From the author.

Annual report of the board of regents of the Smithsonian institution, for 1875. Washington, 1876. From the Institution.

Report of the Commissioner of Agriculture, for 1875. From the Department.

Lectures delivered on Iron Metallurgy, by I. R. de Ibarrola, C.E., Mexican Society of Civil Engineers and Architects. (Two copies) on a translation. From the Society.

Plan of steam, water and sewer pipes in Machinery Building and annexes, Philadelphia International Exhibition, 1876. From John S. Albert, Chief of Bureau.

Brewers' Industrial Exhibition, Centennial Grounds, Fairmount Park, Philadelphia. Essays on the malt liquor question. New York, 1876.

General account of the Commonwealth of Kentucky, prepared by the Geological Survey of the Commonwealth, for the Centennial Exhibition at Philadelphia, 1876. Cambridge, 1876.

Catalogue of products of Michigan in the Centennial Exhibition of all nations at Fairmount Park, Philadelphia. Lansing, 1876.

The use of the Steam Engine Indicator. By E. Lyman, C.E. New Haven, 1874.

Rules for the construction, inspection and characterization of sail and steam vessels. Buffalo, 1876.

Test of power required for cotton and other machinery, by dynamometer belonging to the Amoskeag Manufacturing Company, etc. By Samuel Weber, C.E., 1874.

Chemin de fer de l'état, Postes, Telegraphes, Marine, etc., etc. Bruxelles, 1875.

Australian Orchids, Sarcochiles Divitiflorces, by R. D. Fitzgerald, F.L.S., Sydney.

From the Authors, through the Reception Room of Franklin Institute at International Exhibition, Philadelphia, 1876.

Catalogue of the Chinese imperial maritime customs' collection, at the U. S International Exhibition, Philadelphia, 1876. Shanghai, 1876.

International Exhibition, 1876, special catalogues of stated displays of live stock. Part I, Horses; Part II, Dogs; Neat Cattle, Sheep and Goats, Part I; Swine, Part II. Also special catalogue of the display of poultry, Oct. 27th to Nov. 6th, 1876. Philadelphia.

Norwegian special catalogue for the International Exhibition at Philadelphia, 1876. Christiania, 1876.

International Exhibition, 1876, at Philadelphia, Portuguese special catalogue. Departments 1–5, Mining and Metallurgy, Manufactures, Education and Science, Fine Arts, Machinery.

Agricultural Hall, ground plan showing passage ways, and spaces for installation of exhibits, No. 1. Half transverse sections of the same building.

Art Gallery and plans of extension to the same.

Horticultural Hall and plan of same.

Machinery Hall, etc., plans of Hall and Boiler Houses. Drawings of plans of steam, water and sewer pipes in Hall and Annexes.

Main Building, installation plan and plans of sections, etc.

Plans of Fairmount Park, Exhibition Grounds, etc. From P. C. De Sauque, Philadelphia.

Annual report of the board of regents of the Smithsonian institutions, etc., for the year 1875. Washington, 1876.

The Empire of Brazil at the universal exhibition of 1876, in Philadelphia.

Smithsonian contributions to knowledge, Vols. 20 and 21. Washington, 1876. From Smithsonian Institution.

Treatise on machine tools, etc., etc., as made by Wm. Sellers & Co., Philadelphia, Pennsylvania. From Wm. Sellers & Co.

Centennial Passenger Traffic of the Pennsylvania Railroad.—The following is extracted from the thirtieth annual report of the company, just issued:

In order to accommodate the immense passenger traffic of the Centennial year, it was necessary to make important changes in the system of tracks in the West Philadelphia yards and at the new Centennial station, all of which were accomplished in time to meet the requirements of the Company. A large passenger station was built immediately opposite the main entrance to the Centennial grounds, and the tracks for the incoming and outgoing trains were constructed in the form of a circle, so that there could be a continuous arrival and departure of trains without interference. This plan worked most satisfactorily; the risk of collisions or other accidents to trains was avoided, and the Company was not only enabled to provide for the increased number of trains over its own lines, but to furnish accommodations for the North Pennsylvania and Bound Brook Lines, and for the Philadelphia, Wilmington and Baltimore Railroad. The movement of all passenger and freight trains, to and from the Centennial Grounds and the station at West Philadelphia, was placed under the immediate charge of Charles E. Pugh, with a sufficient corps of officers under him to take prompt care of the great concentration of traffic at those points.

During the Centennial season, between the 10th of May and the 10th of November, 20,231 passenger trains, with 127,296 cars, and 2,343,499 passengers, arrived at the West Philadelphia Station, Thirty-second and Market streets, and during the same period 22,372 trains, with 141,284 cars, and 2,612.213 passengers, arrived at the Centennial Station, making a total of 42,603 trains, with 268,580 cars, and 4,955,712 passengers. This large movement was accomplished without the slightest injury to any passenger. During the period referred to, 90 per cent. of this whole amount of passenger traffic was handled between the hours of 7 and 11 o'clock in the morning, and 4 and 7 o'clock in the afternoon.

The total amount of baggage received and delivered at the West Philadelphia, Centennial, Kensington and Market Street Ferry Stations, was 730,486 pieces, and of this aggregate but 26 pieces were lost or mislaid, the claims for which, as presented, amounting to the small sum of $1906.99.

It is believed that the volume of the passenger and freight traffic of the lines controlled and operated by the Pennsylvania Railroad Company during the Centennial season was largely in excess of that ever handled by any other company. Its careful and successful movement reflects the highest credit upon the General Manager, and the officers under his charge on the various divisions of the line.

A New Method of Synchronizing Clocks.—A new method of synchronizing clocks has been introduced by Messrs. Barraud and Lund, of Cornhill, who have had granted them by the Post-office authorities the special use of a system of wires for working it. A narrow slit cut in the dial of a clock admits two projecting pins. They are arranged so as to catch the minute hand at given intervals, and to set the clock to true time. The pins, attached to a pair of slotted levers, connect with an electro-magnet. The mechanism required can easily be screwed into its place, and it remains entirely disconnected from the works of the clock. Any number of clocks varying in size and calibre can, on receipt of one time signal, be simultaneously set to accord with each other in accurately denoting Greenwich time. The Bankers' Clearing House immediately availed themselves of the advantages of a system, which will remove the often recurring disputes as to "paying in" within the specified time. Other City Establishments will be provided with the apparatus as soon as the Post-office employees are enabled to extend the requisite facilities. The invention must prove a great boon for all mercantile men, and for railway travelers, etc.

Browning of Iron.[1]—By P. Hess (*Dingl. polyt. J.*, ccxxi, 94—95).—The surface of the iron is painted over with linseed oil and heated, whereby, together with separated carbon, ferroso-ferric oxide appears to be produced, which forms the essential protecting layer. Articles which cannot be heated may be dipped into an acidulated solution of ferric chloride, whereby a black layer of ferroso-ferric oxide is formed, which, when dipped into hot water, becomes firmly fixed on the iron, so that after drying it can be rubbed with linseed oil. The formation of this layer takes place by the reducing action of the iron on the oxide and its salts:

$$4Fe_2O_3 + Fe = 3F_3O_4.$$

[1] Abstracts of Chemical Papers, from the *Journal of the Chemical Society*, for January, 1877.

The advantages of browning with ferroso-ferric oxide (magnetic iron ore or smithy scale browning), consist in the fact that it is done much more quickly than the browning with ferric oxide, and that it is more beneficial to the iron than the latter. By using cuprous sulphide a fine bluish-black layer is obtained, which forms a good protection against rusting. The iron has only to be placed in a solution of cupric sulphate for a few minutes, until a fine copper coating is formed on its surface, which, after having been washed with water, is treated with a solution of sodium hyposulphite (thiosulphate) slightly acidulated with hydrochloric acid, when a bluish-black coating of cuprous sulphide is obtained, which is unaffected by air and water. The surface is then washed with water, dried, and polished.

Artificial Lighting of Rooms.—The artificial lighting of rooms affects the human system, on the one hand, through the change produced in the composition of the air by gases of combustion, and on the other through rise of temperature. These influences have lately been examined by M. Erismann (*Zeitschrift fur Biologie*). In a part of the laboratory 10 cubic metres' capacity, inclosed by wooden and glass walls, various materials were burnt eight hours, viz., stearine candles (six at a time), rape oil, petroleum, and ordinary gas, and the air was drawn off at different heights and analyzed. The results do not pretend to absolute exactness, but a comparison of them is interesting. The tables first show that under all circumstances, and with all sorts of artificial lighting, the air of an inclosed space contains more carbonic acid and organic carbon-containing substances than in absence of such illumination; still, in these experiments the carbonic acid was never greater than 0·6 or 0·7 per 1000, while the proportion of other carbon compounds was very variable, so that the amount of carbonic acid gives no exact criterion for the vitiation of the air. The CO_2 actually found in the air was only a very small fraction of that produced by the combustion; by far the greatest part must have been carried away by the natural ventilation. In comparing the four materials, the proportion of CO_2 and other carbon compounds was reduced to a light strength of six normal candles. It appeared that the petroleum, with lamp of good construction, communicates to the atmosphere, not only less CO_2, but (what is much more important) fewer products of imperfect combustion than the other lighting mate-

rials; and, further, that stearine candles, with the same light-strength, vitiate the air most. As to temperature, that of the lower layers of air, up to a height of 1·5 metres, rose very little during the eight hours, about 2° to 3° on an average, while the upper layers increased considerably in temperature, especially just under the ceiling; this increase, in the case of ordinary gas, rape oil, and petroleum, was 10·5° to 10·8°, in that of candles only 4°. If, however, we take into account the photometric light-effect of the flames during the experiment, it is found that, with equal light-strength, rape oil and gas raise the temperature considerably more than petroleum, and the action of the latter, indeed, came to about that of the candles.—*Nature.*

Industrial Society of Mulhouse.—The number of boilers submitted to the control of the Society in 1876, was 1470, an increase of 138 over the previous year. The change of officers, the installation of new engineers, the necessity of more thoroughly organizing the visiting bureau, and the May Exposition, have interfered somewhat with the trials of machines, but an increased activity is anticipated for the current year, especially in experiments upon the consumption of fuel by different types of motors. The great metallurgical establishments in the neighborhood of Metz, have called for the maintenance of a permanent inspector at that place, and another is to be installed at Strasburg, in order to secure a more regular service for the subscribers in the Lower Rhine district. The number of tests with Watt's Indicator has been 91; with the hydraulic press, 349. Though about 70 serious defects have been discovered, there have been only two accidents. The first was the explosion of an interior tube of a generator, in the establishment of one of the members of the Association in the Grand Duchy of Baden, by which one man was seriously wounded. The explosion was occasioned by a deficiency of water, the night and day watchmen having each neglected to try the gauges at the morning change of watch. The second accident was the suffocation of a workman by ammoniacal and sulphurous vapors. The instruction in the School of Design has been made gratuitous. During the year, 99 pupils of ages varying from 13 to 19 years, have been in attendance, and a number of applicants have been obliged to wait for vacancies, on account of want of room.—*Bulletin de la Soc. Ind. de Mulhouse*, Supplement, Dec., 1876. C.

Cost of Street Cleaning in Paris.—The total cost is about 5,000,000 fr., viz.: Agents, drivers and overseers, 260,000 fr.; implements and disinfectants, 250,000 fr.; sweeping, 2,920,000 fr.; removal of snow, ice and filth, 908,000 fr.; sprinkling, 450,000 fr.; heating offices and miscellaneous expenses, 80,000 fr.—*Annales des Ponts et Chaussées*, January, 1877. C.

Use of Magnesia in Clarifying Sugar.—Sres. Bernard and Ehrman find that the alkalinity of magnesia, and its insolubility in saccharine liquors, fit it for the defecation of fermented cane juice. With a dose of from 3 to 5-thousandths the clarification is complete, and the juice is easily filtered. Any excess of magnesia remains in the scum. Laboratory experiments show an increase of 6 to 7 per cent. in the yield of white sugar, while the quality is not inferior to the best commercial brands. Experiments are to be tried on a larger scale, in order to determine whether magnesia can be economically used in all refineries.—*La Gaceta Industrial*, Jan. 10, 1877. C.

Iridescent Glass.—MM. E. Fremy and Clémandot submit glass, under the influence of heat and pressure, to the action of water containing about 15 per cent. of chlorhydric acid. This produces a permanent pearly lustre which, they believe, will be found a valuable addition to the ornamental processes now employed in glass factories. —*Les Mondes*, Feb. 8; *Acad. Sci.*, Jan. 29. C.

Rotary Magnetic Polarization.—M. Fizeau recommends the insertion in the *Recueil des savants étrangers*, of M. Henry Becquerel's memoir on the above subject. The memoir contains new experimental investigations of the phenomena discovered by Faraday, in 1865, and described by him under the title of "Magnetization of Light."—*Les Mondes*, Feb. 8. C.

Formation of Sulphur Springs.—M. E. Plaugaud found, near the source of a mineral spring which was strongly impregnated with sulphur, a number of fine confervæ, which he washed carefully and left in a flagon of ordinary water. About eight days afterwards, wishing to re-examine them, he was struck with the strong sulphurous odor which escaped from the water. He then instituted experiments, which led him to the following, among other, conclusions: 1. Sulphurous mineral waters owe their formation to the reduction of divers sulphates, under the influence of living bodies, which act as ferments. 2. It is still to be seen whether the sulphuration of the water arises

in any case, without the intervention of ferments. Acetic acid, which is commonly formed under the influence of *mycoderma aceti*, may be produced by platinum sponge; and, in like manner, sulphates may be reduced through a variety of influences.—*Ibid.* C.

Carbonic Acid in Air.—The open air commonly contains about 3·34 parts, by volume, out of 10,000; according to Pettenkofer any excess over 1 part in 1000 is unwholesome. E. Schulze (*Archiv. der Pharmacie*, 1876, v. 209, p. 412) thinks Pettenkofer's limit is too low. In a club room he found 37 parts of carbonic acid, and in a school room from 14·4 to 35·6 parts out of 10,000.—*Dingler's Polyt. Journal*, 223, 2, Jan., 1877. C.

Star-twinkling in Damp Air.—Humboldt observed that in tropical regions the approach of rain is often announced by the twinkling of stars near the zenith. Montigny (Bulletin de l'Académie royale de Belgique, 1876, v. 42, p. 255), observed the intensity of the twinkling for 230 evenings, and found that it increased if a storm or a barometric depression was approaching. When rain is foreboded the glimmer is especially strong.—*Ibid.*

Proposed Improvements in Venice.—Among the engineering projects of "New Italy," is one of Giovanni Antonio Romano, for restoring, at least in some measure, the commercial prestige of Venice. His plan embraces an extension of the railway to the eastern extremity of the island La Giudecca, the building of moles, embankments, wharves, storehouses, yards, docks, stations for passengers and freight, and the union of the State, the Venetian Commune and the Chamber of Commerce, in joint guarantees of bonds for construction, as well as in equable division of the revenues. He represents Venice as the most accessible port for Switzerland and Western Germany, while it might reasonably hope to compete successfully for a large part of the commerce of Eastern Germany. If proper arrangements are made for deepening the channels and keeping them clear, the double approach by Malamocco and by S. Nicolo di Lido, will make the harbor one of the most accessible as well as one of the best in the world. Commercial enterprise, combined with a judicious and liberal policy in the removal of restrictions and in furnishing facilities for trading vessels, ought to invite to such a harbor a large traffic with America, Asia, Africa and Central Europe.—*Il Politecnico*, Dec., 1876. C.

Book Notice.

THE ART OF PROJECTING.—By Prof. A. E. Dolbear. 8vo, pp. 158. Boston, Lee & Shepard. For sale by J. B. Lippincott & Co., Philadelphia.

The author of this little work has very thoroughly accomplished the object, as expressed in the preface, of pointing out to teachers of physical science, and to others who may be interested in experimentation, the usefulness of the magic lantern, and especially of the Porte Lumière and a few other pieces of apparatus which can mostly be extemporized.

This work describes and illustrates a large number of experiments in the department of general physics, acoustics, light, heat, etc., which can be projected on the screen with moderately simple apparatus.

No attempt being made to explain phenomena, there is an absence of technicalities, which, with the clearness of description, aided by ample illustrations, makes it well adapted to the use of amateurs, without impairing its value for the use of teachers. The apparatus and methods described are generally those adopted by eminent experimenters, and are with few exceptions the best. As one of these exceptions, may be noticed the animalcule cage pictured on page 33. This is inexpensive and easily made, but must prove unsatisfactory in use, while those devised by Mr. D. S. Holman, and known as the life and the siphon slides, are so much superior as to have warranted their being mentioned.

In speaking of ice flowers on page 52, it is stated that to exhibit them on the screen it is necessary that the beam of light should consist of parallel rays, and that the block of ice should be one-half to three-quarters of an inch thick. Both these statements are erroneous; much better results are obtained by having the piece of ice quite thin, say less than one-quarter of an inch thick, taking care that it is kept at as low a temperature as possible before using.

The intensity of the illumination and consequent brightness of the pictures, are obtained by using a converging beam of light, and placing the piece of ice near where the rays cross. If these conditions are carefully observed, quite clear, well-defined pictures can be obtained.

The wide field covered, and the care with which it is prepared, make this book deserving of a place in the hands of all interested in illustrations of this character. K.

Civil and Mechanical Engineering.

ON THE LOSS OF HEAT BY RADIATION FROM STEAM BOILERS, AND THE ECONOMIC VALUE OF BOILER CLOTHING.

By J. C. Hoadley.

That heat escapes rapidly by radiation from the outside of steam boilers containing steam of high pressure, when the surface is unprotected, is familiar to all. That clothing or covering with wood, or felt, or with a cement of asbestos, gypsum, or some other feeble conductor of heat, lowers the temperature exposed to the air, and so diminishes the loss by radiation, is also well known.

What is not so generally known, or so accessible, if the knowledge exist at all, is the exact ratio of loss under certain definite conditions, such as we often meet in practice, and the economic value of certain admissible kinds of clothing. The saving effected by clothing boilers, pipes and other vessels containing steam, cannot be considered as inversely proportioned to the conducting power of the material used for clothing. The outer surface is more or less enlarged, and radiation, if less active, goes out from the enlarged surface. If the material of the outer covering be a better radiator than iron, as it will be of necessity if a poorer conductor, the loss may be very great while the radiating surface feels only moderately warm to the hand. Just what the loss is in a given boiler under familiar conditions, what ratio this loss bears to the steam generating power of the boiler, and what saving can be effected by clothing of some convenient kind, are facts not generally known, and such data as have been established by observation and experiment, are neither very accessible nor easily applied in practice.

Nearly all boilers of much importance in use for stationary purposes, are effectively protected by brickwork, with ashes or other similar material on top. Locomotives, exposed as they are to all the rigors of the elements, to wind, snow and rain, have usually something more than half of their exterior in some degree protected with a covering, generally of wood, cased with sheet iron.

Portable steam engines are, in England, almost universally covered about as locomotives are. The waist, or barrel, is generally covered while the fire-box casing is usually left naked. In this country, any covering at all is the rare exception.

Having had on exhibition (in use) at the International Exhibition in Philadelphia, an engine of the class styled in England "semi-portable," or self-contained, but usually classed in this country among "portable engines," and having had this engine ($14{\cdot}5'' \times 20''$) tested for economy in September last, I was led to make some experiments to ascertain the extent of loss to which the boiler would be subject by reason of its exposure, entirely naked, to the air of the engine-room, the radiating surface being equal to about two-fifths of the heating surface.

These experiments twice repeated, gave, at the more useful pressures—90 to 120 pounds above atmosphere—a loss of 9 to 11 per cent. of the steam generating power of the boiler as usually fired for its normal work, about 80 h. p. It was still a matter of doubt how far this loss could be reduced by any practicable method of clothing; and the importance of the subject, and the interest awakened by the experiments above mentioned, induced me to carry the investigation further at the first opportunity. Such an opportunity soon offered. We were making a portable engine of sixty horse power for Messrs. William Sellers & Co., for use in a mill of which they are proprietors, at a short distance from Philadelphia, and, by agreement, the boiler was to be covered.

Experiments on radiation were carefully made, first, before clothing the boiler, and again afterwards, with results exhibited on the accompanying diagram, which, together with the manner of conducting the experiments, will be explained somewhat in detail.

The boiler having been tested and found to be tight with 150 lbs. pressure by steam gauge, steam was reduced to atmospheric pressure, with water at about normal water line ($2\frac{1}{2}$ in. above top of crown sheet), and a good fire of dry wood was started, with the safety-valve wide open. When the fire was at its hottest, with a good mass of glowing coals and partly burned wood at bottom, the fire-box was filled with a compact firing of dry wood, and the safety-valve was closed. Time was noted at the instant of closing the fire-door and safety-valve,—pressure 0, by steam gauge, = atmosphere; and the time, to the nearest second, at which each 2·5 lbs. increase of pres-

sure was reached, was also observed and noted. As the number of thermal units to be imparted to the boiler and its contents—water and steam—to produce a given increase of pressure, grows less and less as the pressure rises, the line which represents the ascending pressure on the diagram, in which the abscissæ represent times and the ordinates pressures above the atmosphere, is a curve which could be calculated upon the assumption that the heating power of the fire was either constant or variable, according to some known law. The assumption adopted, that the heating value of the fire was sensibly constant during the period of time, 39·4 minutes, occupied in raising steam pressure from 0 to 140 lbs. above atmosphere, can hardly be exactly correct, but is probably quite near enough for the purposes of the experiment.

Without going into details which would hardly repay perusal, it is enough to say that taking into account the weight of the boiler and its attachments which are heated by the steam and hot water, and the specific heat of iron; the weight of water below the water line and its specific heat as modified by temperature; and the augmenting weight of steam in the steam-space and its diminishing ratio of increase of heat, all expressed in thermal units, the abscissæ for each increase of 10 lbs. in the pressure, as the same are computed, and observed, compare as follows:

Pressures by steam-gauge, pounds per square inch.	Abscissæ, time in minutes, computed.	Abscissæ, time in minutes, observed.
From 0 to 10	5·0	7·5
" 10 " 20	3·5	4·3
" 20 " 30	2·8	3·3
" 30 " 40	2·3	2·5
" 40 " 50	2·0	2·1
" 50 " 60	1·8	1·9
" 60 " 70	1·6	1·7
" 70 " 80	1·5	1·4
" 80 " 90	1·3	1·3
" 90 " 100	1·2	1·2
" 100 " 110	1·2	1·2
" 110 " 120	1·1	1·1
" 120 " 130	1·	1·
" 130 " 140	1·	1·
" 140 " 150	·9	·9

From this comparison it would appear that the fire gained in intensity during the first nineteen or twenty minutes, while the steam

pressure was going up to 50 lbs., and from that point remained sensibly constant, there being substantial agreement between the observed and computed times.

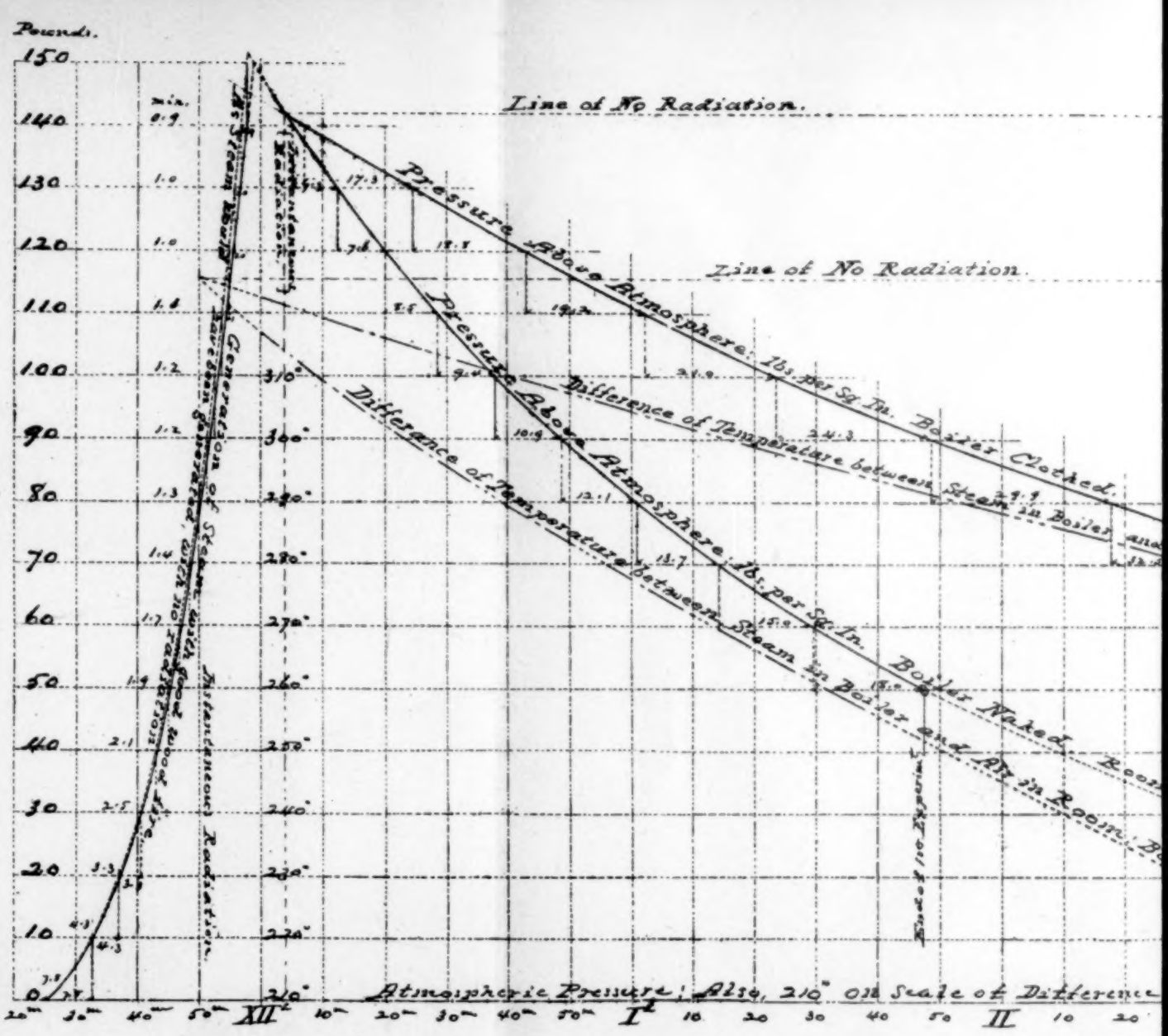
The steeply-rising full line at the left hand shows the resulting curve as observed; while the more steeply-rising dotted line near it, shows the same curve corrected for the simultaneous radiation.

When a pressure of 150 lbs. by steam gauge had been reached, the fire was rapidly withdrawn, removed to a little distance and quenched. A well fitted door of battened boards was placed under the fire-box hoop, and wedged up closely, and the smoke-pipe was removed and the outlet of the smoke-box closed. During these operations the steam pressure first rose and then fell a few pounds; but the rise and fall above 150 lbs., although noted, are omitted from the diagram, being affected by disturbing causes, such as the open doors, the draught of cold air through the flues, etc.

Cooling now being reduced to radiation from the outside of the boiler, including the steam jacket of the cylinder, the time occupied in falling from 150 lbs. to 50 lbs. was carefully noted for each 2·5 lbs. of pressure. The results, for intervals of 10 lbs. of pressure, are subjoined:

Pressures, pounds per sq. in.	Time, Minutes.	Pressures, pounds per sq. in.	Time, Minutes.
From 150 to 140	7·1	From 100 to 90	10·9
" 140 " 130	7·3	" 90 " 80	12·1
" 130 " 120	7·6	" 80 " 70	13·7
" 120 " 110	8·5	" 70 " 60	15·0
" 110 " 100	9·4	" 60 " 50	18·0

It is obvious that the time occupied in reducing the pressure by 10 lbs., at any point in the scale, is to the time occupied in raising the pressure the same amount at the same point, as radiation from the cooling surface is to absorption by the heating surface. The time of raising steam pressure, then, divided by the time of losing the same pressure by radiation, expresses the ratio of radiation to steam generation. Thus, between 50 and 60 lbs., 1·9 minutes sufficed to raise the pressure 10 lbs., while 18 minutes were required to reduce it as much. Therefore, $\frac{1·9}{18} = ·106$, = 10·6 per cent. = ratio of radiation to absorption at this point. These ratios will be found in the second column of table on the accompanying diagram.


Pounds.
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Line of No Radiation.
Pressure Above Atmosphere. lbs. per Sq. In. Boiler Clothed.
Line of No Radiation.
Pressure Above Atmosphere. lbs. per Sq. In. Boiler Naked.
Difference of Temperature between Steam in Boiler
Difference of Temperature between Steam in Boiler and Air in Room.
Atmospheric Pressure.
Area 210° on Scale of Difference
Generation of Steam
Radiation
Ratio of Generation of Steam to Radiation
Ratio of Steam Generated to Radiation
Ratio of Steam Generated to Radiation
Ratio of Steam Generated

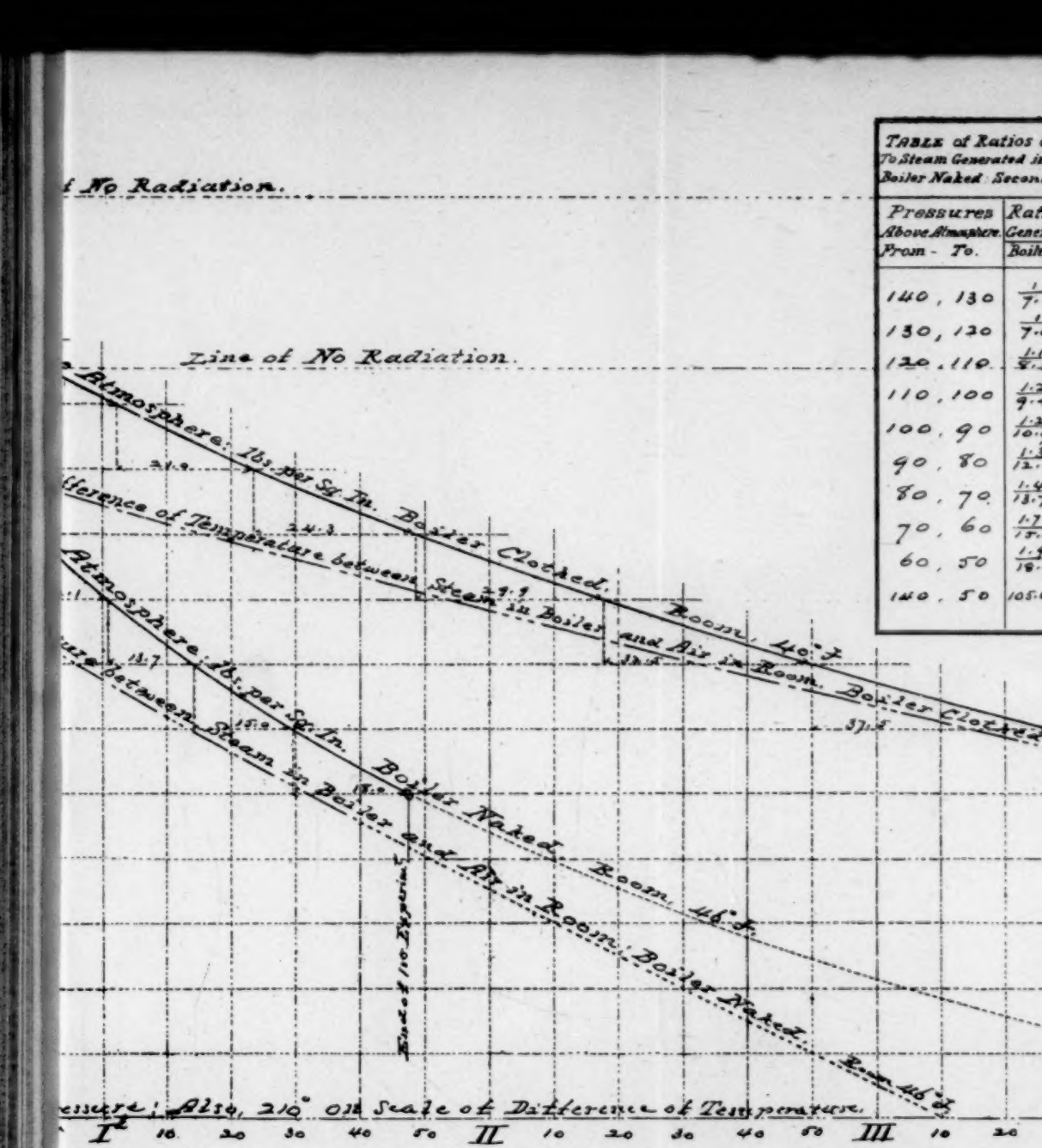


TABLE of Ratios
To Steam Generated i
Boiler Naked Secon

Pressures Above Atmosphere. From - To.	Rat Gene Boil
140 , 130	1/7.
130 , 120	1/7.
120 , 110	1/8.
110 , 100	1/9.
100 , 90	1/10.
90 , 80	1/12.
80 , 70	1/13.
70 , 60	1/15.
60 , 50	1/18.
140 , 50	105.

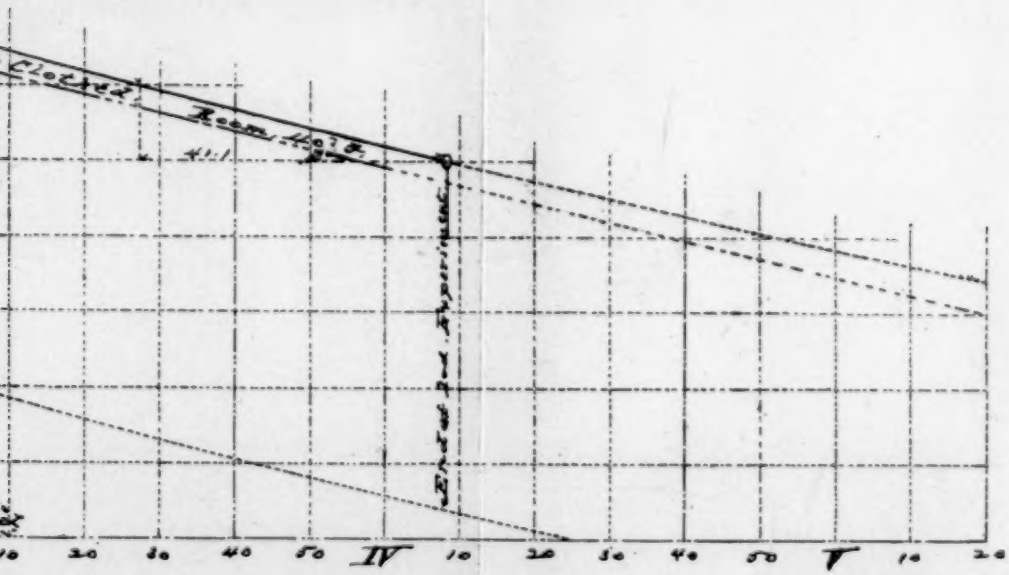
f No Radiation.

e effect of Boiler Clothing in retarding Radiation of Heat and
274·60 H.P, 12·5 in. cyl. 18 in. Str. Regulated to run light, at 182 Rev. per M.;
ley Company, Lawrence, Mass. — For William Sellers & Co., Philadelphia.

I.C. Hoadley. Jan. 18. 1877.

E of Ratios of loss of PRESSURE by Radiation of HEAT.
m Generated in equal times, at equal pressures: First, with
Naked: Second, with Boiler Clothed: Asbestos & in Hair Felt.

ssures Atmosphere. To.	Ratio of Radiation to Steam-Generated at equal P. in equal Times. Boiler Naked.	Boiler Clothed.	Ratio: Clothed to Naked Boiler. Rad.: Per Cent.
, 130	$\frac{1}{7.3}$ = 13.7 %	$\frac{1}{17.3}$ = 5.8 %	$\frac{7.3}{17.3}$ = 42.2 %
, 120	$\frac{1}{7.6}$ = 13.2 %	$\frac{1}{18.8}$ = 5.3 %	$\frac{7.6}{18.8}$ = 40.4 %
, 110	$\frac{1.1}{8.5}$ = 12.9 %	$\frac{1.1}{19.2}$ = 5.7 %	$\frac{8.5}{19.2}$ = 44.3 %
, 100	$\frac{1.2}{9.4}$ = 12.8 %	$\frac{1.2}{21.0}$ = 5.7 %	$\frac{9.4}{21.0}$ = 44.8 %
, 90	$\frac{1.2}{10.9}$ = 11.0 %	$\frac{1.2}{24.3}$ = 4.9 %	$\frac{10.9}{24.3}$ = 44.8 %
, 80	$\frac{1.3}{12.1}$ = 10.7 %	$\frac{1.3}{29.9}$ 4.3 %	$\frac{12.1}{29.9}$ = 40.5 %
, 70	$\frac{1.4}{13.7}$ = 10.2 %	$\frac{1.4}{32.8}$ 4.3 %	$\frac{13.7}{32.8}$ = 40.9 %
, 60	$\frac{1.7}{15.0}$ = 11.3 %	$\frac{1.7}{37.5}$ 4.5 %	$\frac{15.0}{37.5}$ = 40.0 %
, 50	$\frac{1.9}{19.0}$ = 10.6 %	$\frac{1.9}{41.1}$ 4.6 %	$\frac{19.0}{41.1}$ 43.8 %
, 50	105.65 : 250.5	1 : 2.35	Mean = 42.6 %



t and Reduction of Pressure: Dec. 18. 1876; Jan. 12. 1877.
per M.; loaded, at 175 Rev. per M.
lphia. Delivered on cars, Jan. 16. 1877.—

TABLE OF RATIOS OF LOSS OF PRESSURE BY RADIATION OF HEAT TO STEAM GENERATED IN EQUAL TIMES: FIRST, WITH BOILER NAKED; SECOND, WITH BOILER CLOTHED, ASBESTOS, ¾ IN. HAIR FELT, ¾ IN. GALVANIZED SHEET-IRON CASING.

Pressures per sq. in. above atmosphere.	Ratios of Radiation to Steam Generation at Equal Pressures in Equal Times.		Ratio of Radiation from Clothed Boil. to that from Nak'd Boiler.
	BOILER NAKED.	BOILER CLOTHED.	
From	Per Cent.	Per Cent.	Per Cent.
140 to 130	$\frac{1\cdot}{7\cdot3} = 13\cdot7$	$\frac{1\cdot}{17\cdot3} = 5\cdot8$	$\frac{7\cdot3}{17\cdot3} = 42\cdot2$
130 " 120	$\frac{1\cdot}{7\cdot6} = 13\cdot2$	$\frac{1\cdot}{18\cdot8} = 5\cdot3$	$\frac{7\cdot6}{18\cdot8} = 40\cdot4$
120 " 110	$\frac{1\cdot1}{8\cdot5} = 12\cdot9$	$\frac{1\cdot1}{19\cdot2} = 5\cdot7$	$\frac{8\cdot5}{19\cdot2} = 44\cdot3$
110 " 100	$\frac{1\cdot2}{9\cdot4} = 12\cdot8$	$\frac{1\cdot2}{21\cdot} = 5\cdot7$	$\frac{9\cdot4}{21\cdot} = 44\cdot8$
100 " 90	$\frac{1\cdot2}{10\cdot9} = 11\cdot0$	$\frac{1\cdot2}{24\cdot3} = 4\cdot9$	$\frac{10\cdot9}{24\cdot3} = 44\cdot8$
90 " 80	$\frac{1\cdot3}{12\cdot1} = 10\cdot7$	$\frac{1\cdot3}{29\cdot9} = 4\cdot3$	$\frac{12\cdot1}{29\cdot9} = 40\cdot5$
80 " 70	$\frac{1\cdot4}{13\cdot7} = 10\cdot2$	$\frac{1\cdot4}{32\cdot5} = 4\cdot3$	$\frac{13\cdot7}{32\cdot5} = 42\cdot2$
70 " 60	$\frac{1\cdot7}{15\cdot0} = 11\cdot3$	$\frac{1\cdot7}{37\cdot5} = 4\cdot5$	$\frac{15\cdot}{37\cdot5} = 40\cdot0$
60 " 50	$\frac{1\cdot9}{18\cdot0} = 10\cdot6$	$\frac{1\cdot9}{41\cdot1} = 4\cdot6$	$\frac{18\cdot}{41\cdot1} = 43\cdot8$
140 " 50	$\overset{M}{105\cdot65} : \overset{M}{250\cdot5} = 1 : 2\cdot35$		= Mean, 42·6

There are some slight irregularities owing, probably, to the manner of conducting the experiments; but the several ratios are, on the whole, mutually confirmatory. At the more useful pressures, 80 or 90 lbs. to 120 or 130 lbs. above the atmosphere, the loss appears to be 11 to 13 per cent.

The corresponding curve of temperatures, shown below the curve of pressures, is obtained from the tables of the temperature of steam

at given pressures. For this purpose the scale of pressures is made to serve as a scale of degrees of temperature by adopting an arbitrary zero, such that 210° falls on the line of 0 pressure, the temperature of the engine room (46°) being deducted from that of the steam. The relation between the scale of pressures and that of temperatures, is purely arbitrary, and is adopted merely for convenience. The loss of heat is seen to be much more nearly in direct proportion to the time, than is the loss of pressure.

The boiler was afterwards clothed, first with three-quarters of an inch of asbestos cement, securely held in place by a sort of "lathing" of wire cloth of $\frac{1}{2}$ inch mesh, and over the asbestos a covering of hair felt, which when slightly compressed by the outer casing of galvanized sheet iron, was also about $\frac{3}{4}$ inch thick, making the whole covering about 1·5 inches. Around the smoke-box the entire thickness was of asbestos cement. This covering was complete over the fire-box casing including the door-end as well as around the barrel of the boiler, but did not extend over the steam jacket casing of the cylinder. There was also a space about 6 inches in height at the bottom of the fire-box, all around, which was left uncovered for convenience of access to hand-holes, mud-plugs and blow-off cock. This space, in setting, can mostly be covered with brickwork.

The process of raising steam was not again noted, as it was thought to be impracticable to make a second fire which should be known to be sufficiently like the first one, to admit of useful comparison; but loss of pressure by radiation was very carefully noted, the time being taken as each successive pound was reached, as well as each 2·5 lbs., the steam gauge being graduated to pounds. So much less heat escaped from the boiler that, although the day was rather warmer than at the first experiment, the engine-room (which had no other heat), was 6° Fahr. cooler than before: then 46°, now 40°.

The result of these observations is shown by the upper curve of the diagram; the corresponding fall of temperature by the curve, differing but little from a straight line, immediately below. The ratio of loss under these conditions to steam generated in the first experiment, is shown, for each interval of 10 lbs., from 140 lbs. down to 50 lbs., in the third column of table, and appears to be, for the same range of useful pressure before taken, 80 or 90 to 120 or 130 lbs. from 4 to 5 per cent., and the difference of ratios, which is the apparent saving effected by the clothing, about 7 per cent.

The times required by the naked boiler to reduce the pressure 10 lbs. at each stage, divided by the corresponding times required by clothed boiler, to effect the same reduction, show the ratio of loss by the clothed boiler to that by the naked boiler. For instance, between 50 lbs. and 60 lbs. the radiation from the naked boiler produced in 18 minutes an effect (10 lbs. fall of pressure), equal to that which the clothed boiler occupied 41·1 minutes in producing; therefore, $\frac{18}{41{\cdot}1} = {\cdot}438 = 43{\cdot}8$ per cent., is the ratio at this point. These ratios will be found in the fourth column of the table. They are nearly constant, and their mean is 42·6 per cent. No correction is attempted for the 6° difference of temperature. Its effect is a slight understatement of the advantage of the boiler clothing.

What, then, is the economic value of such boiler clothing?

If the consumption of coal for 60 horse power is one ton per day of ten hours, say 300 tons per annum, a saving of 7 per cent. will be 21 tons per annum, amounting, at $6.00 per ton, to $126.00, rather over one-half the cost of the clothing. This, although less perhaps, than is commonly supposed, is an important saving. There are also obvious advantages in keeping up steam better during noontime, and whenever the engine is stopped. Perhaps a more efficient covering could be applied without making it too thick and cumbrous to be admissible on a portable engine boiler. The same total thickness here used, if entirely of felt, would be more efficient; but the felt would soon become charred. From this, the asbestos probably protects it. If ·7 or ·8 of the entire loss could be intercepted, the economy would be important. There is some incidental economy from the use of dryer steam, as all radiation from the iron around the steam space, leaves some water suspended in the steam or deposited on the inner surface of the boiler plates. The effect of having 7 per cent. less water to evaporate in a unit of time is also in the direction of economy. It is to be hoped that further contributions may be made to our knowledge of this important subject.

The table on the diagram is here reproduced for convenience of consultation. The dimensions of the boiler are also subjoined. The steam gauge used was one of the American Steam Gauge Company's 10″ standard gauges, which has never before been used exept to test other gauges by, and has been at three different times compared with a mercury column, with which it nearly agrees.

DIMENSIONS OF BOILER: ENGINE $12{\cdot}5'' \times 18''$.

Diameter of barrel, inside, inches,		38
Thickness of iron in all outside sheets, inches,		$\frac{3}{8}$
" steel in all inside sheets, inches,		$\frac{3}{8}$
Length of fire-box, inside, "		54
Width " " "		33
Height " " above bottom of hoop, inches,		47
" " " " top " "		45·25
" " " " " of grates, "		43
Size of doors (2 doors) in clear, inches,	10×16	
" " outside of hoop, "	$13{\cdot}5 \times 19{\cdot}5$	
Number of screw stay-bolts in door end,		41
" " " further end,		30
" " " both sides,	$81 \times 2 = 162$	
Diameter of " " inches,		$\frac{5}{8}$
Width of water space, door end and sides, inches,		$1\frac{3}{4}$
" " " further end, inches,		$2\frac{1}{2}$
Number of crown bolts,		60
Diameter of crown bolts, inches,		$\frac{1}{2}$
Number of double crown bars,		10
Length " " " inches,		33·75
Dimensions of iron in crown bar, "		$4 \times \frac{1}{2}$
Arrangement of crown bars, 5 in. from c. to c. across fire-box.		
Longitudinal seams double-riveted.		
Number of flues, lap-welded iron,		63
Diameter of flues, outside, inches,		$2\frac{1}{4}$
" " inside, "		2
Length " inches,		108
" in clear between flue sheets, inches,		107
Heating surface, fire-box, total, square feet,		65·2
" " " above hoop, square feet,		61·48
" " " " grates, "		58·76
" " flues, outside, "		330·90
" " " inside, "		294·13
" " smoke-box, "		6·14
	65·20	
	330·90	
" " total, square feet,	6·14	402·24
	58·76	
	294·13	
" " above fire-grates and inside of flues,	6·14	359·93
Area of surface of water at 2·5 in. above top of crown sheet, sq. ft.		38
" fire-grate, $4{\cdot}5 \times 2{\cdot}75$ square feet,		12·375
Ratio of heating surface, gross to area of fire-grate, $\frac{402{\cdot}24}{12{\cdot}375} = 32{\cdot}5$		
" " " net " " $\frac{309{\cdot}03}{12{\cdot}375} = 25$		

ON THE LANCASHIRE BOILER,

ITS CONSTRUCTION, EQUIPMENT, AND SETTING.

By Mr. Lavington E. Fletcher, of Manchester.

[Continued from Vol. cliii, page 206.]

The mudhole *A*, Figs. 1 and 2, at the front of the boiler, beneath the furnace-tubes, is also fitted with a substantial mouthpiece. This in some cases is external, like the manhole mouthpiece, and in others internal as shown in Fig. 1. The internal ones have the advantage of being less in the way. In either case the surfaces at the joint between the body of the mouthpiece and the cover are faced true, so that the parts may be brought together metal to metal.

The safety-valves *E*, and *F*, and the steam stop-valve *G*, are fixed to the shell, each with its own independent opening, and not grouped upon the manhole mouthpiece as is sometimes the case, the object of grouping them being to reduce the number of holes, on the principle that the fewer holes made in a boiler the better. This argument is plausible but fallacious. The manhole makes the largest opening, and therefore exerts the greatest weakening effect. The weakest link in a chain is the measure of the strength of the whole; so that fixing the steam stop-valve and safety-valves directly to a boiler with suitable fitting blocks does not weaken it. Moreover, for convenience in attaching the fittings, these group manhole mouthpieces are made of cast iron, which as already explained is objectionable. It is therefore recommended that manhole mouthpieces should not be complicated by the addition of the safety-valves or other fittings, but that each should be fixed direct to the shell and have its own independent attachment and thoroughfare.

Blocks for the Attachment of Fittings.—In old-fashioned practice the fittings were bolted directly to the cylindrical portion of the shell. This led to the wasting of the shell through leakage at the joints; so that it has long since been the practice to rivet short stand-pipes to the cylindrical portion of the shell and bolt the fittings thereto, the joint surface between the flanges being planed up true. These stand-pipes, frequently termed "fitting blocks," are not only more conve-

nient for the attachment of the fittings, but also, being riveted to the plate and made of substantial section, strengthen the plate round the hole cut in the shell. They are as a rule made of cast-iron, but it becomes a question whether, with the high pressures now in use, they should not be made of wrought iron. At one of the experimental bursting tests, a fitting block for a 6 in. steam valve-box was found to give way before any other part of the boiler, at a pressure of 275 lb. per square in., though the flange was $1\frac{3}{8}$ in. thick, the body $\frac{7}{8}$ in., and the metal sound.

Seams of Rivets.—Those running longitudinally in the cylindrical shell are all double-riveted, with $\frac{3}{4}$ in. rivets pitched about $2\frac{1}{2}$ in. longitudinally and 2 in. diagonally. The remaining seams throughout the boiler are single-riveted only, the rivets being 2 in. pitch. To double-rivet the transverse seams adds but little, if any, strength to the boiler, though it increases its weight and cost. It would appear that the strain upon the transverse seams of rivets in a Lancashire boiler is over-estimated. In a plain cylindrical boiler, without furnace-tubes, the strain on the transverse seams of rivets is precisely half that on the longitudinal seams. By the introduction of the furnace-tubes not only is the longitudinal strength increased, but at the same time the area of the ends upon which the steam acts is lessened, and thus the strain is lessened also; so that in the Lancashire boiler the strain on the transverse seams of rivets is less than half that on the longitudinal seams. The force of this reasoning however is sometimes disputed, and tie rods are introduced to support the transverse seams of rivets in the shell. But in the hydraulic bursting tests, with the tie rods removed, the longitudinal seams of rivets were found to fail in every case before the transverse seams, which never showed the slightest signs of distress and scarcely leaked a drop, while some of the longitudinal seams under severe pressure shortly before rupture leaked profusely.

The riveting is done by machine in preference to hand in the cylindrical shell, in the furnace-tubes, and as far as practicable in the flat ends. In the experimental bursting tests, the machine work in every case proved much tighter than the hand work. The rivet holes in the angle irons, T irons, and flanged seams are drilled, those in the plates being punched by most makers; though by some the holes are drilled throughout, and the practice of drilling is strongly advocated by them. In investigating an explosion that occurred at

Blackburn in March, 1874, the mean tensile strength in twelve tests of a solid plate was found to be 21·19 tons per sq. in., and in four tests of a punched plate 20·17 tons, showing a loss by punching of 1·02 tons per sq. in., or about 5 per cent. The question of drilling versus punching, and also of the pitch and diameter of rivets, is one that deserves further consideration; and it may be added that a boiler 7 ft. diameter, and made of plates $\frac{7}{16}$ in. thick, having the longitudinal seams double-riveted with $\frac{3}{4}$ in. rivets, pitched 3 in. longitudinally, instead of $2\frac{1}{2}$ in. as usual, was found tight at a hydraulic pressure of 120 lb. per sq. in. The edges of the plates at the longitudinal seams of rivets are planed and calked lightly, inside as well as out; though in many cases calking is superseded by fullering.

Material.—As a rule, boilers made under the inspection of the Manchester Steam Users' Association are of iron in the shell, while steel plates are very frequently introduced in the furnace-tubes for a length of 9 ft. over the fire, and sometimes from one end of the boiler to the other. For the furnace-tubes steel plates have been found to give great satisfaction, but a little suspicion has been entertained with regard to their use for shells, seeing that the plates are then in tension, and that a small flaw through brittleness might extend till it produced serious consequences. "Best best" plates from first-class makers are always recommended, more importance being attached to their ductility than to their tensile strength. Brands however are uncertain, and it is thought desirable that a complete system of testing should be adopted, and that, before a boiler is made, one plate out of the set proposed to be used should be tested as a check, the investigation having special reference to ductility. Low Moor rivets are frequently used and may be recommended.

Equipment.

Arrangement of Fittings.—The fittings are so arranged that all those requiring frequent access are immediately within reach of the attendant when standing in front of the boiler. The feed is introduced on one side of the front end plate, about 4 in. above the level of the furnace crowns, an internal dispersing pipe *H*, Figs. 1 and 3, being carried along inside the boiler for a length of about 12 ft., and perforated for the last 4 ft. of its length. On the opposite side of the front end plate is fixed the scum tap, to which is connected a series of sediment-catching troughs *K*, Fig. 3, fixed inside the boiler.

In the centre of the end plate are two glass water-gauges *J J*, Fig. 2, so that one may act as a check upon the other, a pointer being fixed to show the correct height at which the water should be kept. Immediately above the water-gauges is a dial pressure-gauge *L*, and above that a dead-weight safety-valve *E*. Thus whenever the attendant opens the furnace doors to charge the fires, he has the height of the water and the pressure of the steam directly before him. Under his feet is the blow-out tap, and behind him the coal supply, so that everything is ready to hand. He has not to climb a ladder in order to reach the water-gauges or ascertain the steam pressure, nor to mount on the top of the boiler in order to regulate the feed supply. A handle for regulating the dampers is frequently brought to the boiler front. On the top of the boiler are two safety-valves, one a dead-weight valve *E*, of external pendulous construction, the other a low-water valve *F*, Fig. 1.

But convenience in manipulation is not the only reason for this arrangement of fittings. If the feed be cold and be introduced near the bottom of the boiler, it is apt to induce local contraction, and thereby strain the transverse seams of rivets at the bottom of the shell; but when introduced near the surface of the water and passed through an internal perforated pipe, it becomes dispersed before falling to the bottom. Further, although non-return valves may be introduced, they will sometimes fail and allow the water to escape, whereby the furnace crowns become bare and overheated. When the feed inlet is placed above the level of the furnace crowns, it will be seen that they cannot be drained bare by leakage at the non-return valve; but when placed at the bottom of the boiler, the boiler may then be emptied by such an occurrence.

Safety-Valves.—The dead-weight valve, which is of the Cowburn type, as shown in Fig. 10, Plate V, is extremely simple and efficient. The centre of gravity of the load being below the seating renders unnecessary either wing or fang for keeping the valve in position, and it has therefore no frictional surface to get tight or stick fast. These valves are loaded with flat annular plates or rings, and the shell is cast with mouldings around it at the bottom which present the same appearance, the whole being so adjusted that each moulding as well as each annular plate represents a pressure of 5 lb. per sq. in. on the valve. Large numbers of these valves are in use, and they are highly approved. The diameter generally adopted is 4 in., which requires

approximately a load of 8 cwt. for a blowing-off pressure of 75 lbs., and 11 cwt. for 100 lb. per sq. in. On this valve the addition of two or three bricks produces no appreciable effect, whereas at the end of a long lever the result would be different. To double the blowing off pressure it would be necessary to add about 8 cwt. to the load for 75 lb., and 11 cwt. for 100 lb. Such an addition there would be great difficulty in attaching to the valve, and if it were done it would be so conspicuous as at once to call attention to the fact. The great weight required to load this valve is considered therefore to be a safeguard: and several explosions due to overloading have been met with, which would have been prevented by its use.

The low-water safety-valve shown at *F*, in Fig. 1, is of the Hopkinson type; but there are also the Kay and the Lloyd low-water valves, which though varying in detail are similar in their object. Each has a lever inside the boiler, to which is attached a float, so that when the water falls below the desired level the float falls also, and thus raises the valve and allows the steam to blow off, thereby not only giving an alarm but also lowering the pressure. Hopkinson's valve is a compound one, having one valve seated on another; the central portion is loaded by a dead weight inside the boiler, and operated upon by the lever in the event of low water, while the annular portion is loaded by an external lever and weight, and lifts along with the central portion in the event of high steam; these valves therefore blow off on the occurrence either of high steam or of low water. The outer valve is 5 in. diameter, and the inner one 2½ in. The freedom of the steam valve can be tested by placing the hand on the lever when steam is up; while the freedom of the low-water apparatus can be tested by opening the blow-out tap and lowering the water-level to within about 6 in. of the furnace crowns. To overload this valve without increasing the weight outside would necessitate getting inside the boiler and wedging down the dead weight. Under such circumstances the application of the hand to the external lever when steam was up would at once show that something was wrong; and even if this were not detected the external dead-weight valve at the front of the boiler, if free, would come to the rescue, while, if overloaded, this would be apparent at a glance. It is sometimes recommended to have safety-valves under lock and key, but it is preferred by the writer to have them thoroughly open, so that their publicity may be their protection. While it is fully admitted that no arrangement of safety-

valves can be contrived which cannot be tampered with by skilled malice, it is thought that the combination of the two valves just described and shown in Fig. 1, forms a very safe arrangement.

Furnace Mountings.—The furnace mouthpieces *N N*, Fig. 2, are of wrought iron, finished off with a neat brass beading, and kept within the circle of the rivets, so as to leave these exposed to view. The fire-doors are fitted with a sliding ventilating grid on the outside and a perforated box baffle-plate on the inside, the aggregate area of the air passages being about 50 sq. in. for each door, or about 3 sq. in. per sq. ft. of firegrate. The firegrate is 6 ft. long, with the bars in three equal lengths, about $\frac{1}{4}$ in. thick, and spaced $\frac{3}{8}$ in. apart for windage. The bearers consist of two wrought iron bars carried on wrought-iron brackets riveted to the sides of the furnace-tubes. The standard length of grate is 6 ft., but a shorter one is productive of economy, though the concentration of the fire is more trying to the boiler, and has been found, where the feed water has not been good, to injure the furnace plates, and render lengthening the grate necessary.

Setting.

External Brickwork, Flues, and Course of Draught.—The boiler is set on side walls, and rests on firebrick seating blocks presenting a bearing surface 5 in. wide, as shown in Fig. 3, Plate III. The side flues are 6 in. wide at the top, carried up to the level of the furnace crowns or a few inches above, and down to the level of the bottom of the shell. The bottom flue has a width equal to the radius of the boiler, and a depth of about 2 ft. These dimensions admit of ample room for inspection. By keeping the width of the bottom flue equal to the radius of the boiler, the angle that the bearing surface of the seating block makes with the horizon is 30° for any diameter of shell.

The flame immediately after leaving the furnace-tubes passes under the bottom of the boiler, and returns to the chimney along the side flues. This is not the course approved by Mr. Pole in his treatise on the Cornish Pumping Engine, published in "Tredgold on the Steam Engine" in 1844, in which the setting of the Cornish boiler is spoken of as follows:—"The heated current first impinges on the top of the tube, over which the highest and therefore the hottest portion of the water is lying; it then passes along the side flues, where it finds the

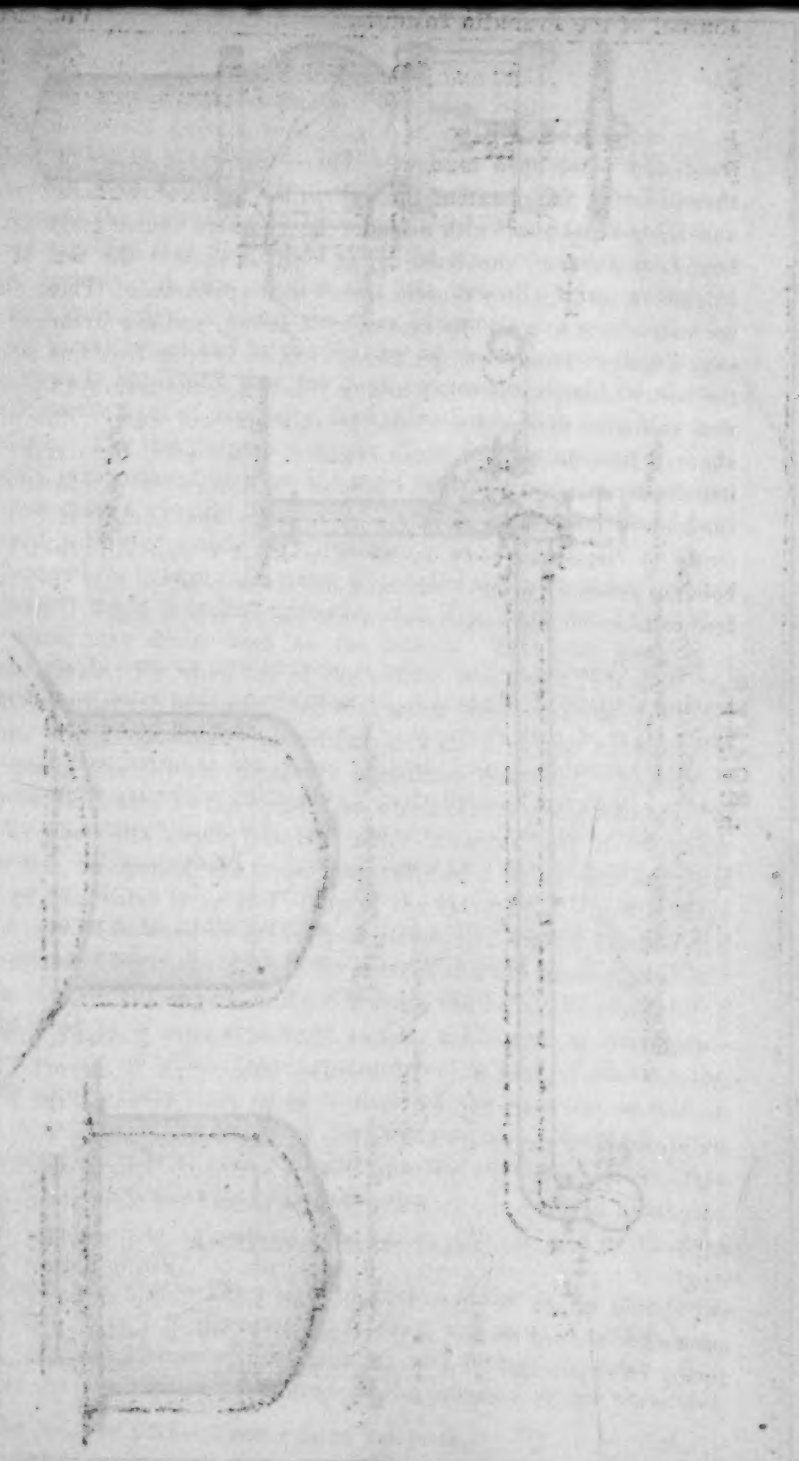
surfaces cooler than before; and last of all it traverses under the bottom of the boiler, where the coldest water will always be. By this means the fire current, as it gradually cools, is likewise gradually brought to act upon cooler water, and thereby the best opportunity is afforded for the extraction of the free caloric it contains. . . . . The descending motion of the fire current, as it cools in the flues of the Cornish boiler, is upon statical principles much more natural and calculated to prevent the unnecessary discharge of heat into the chimney than the ascending principle of the ordinary boilers." Allowing the last heat however to travel under the bottom of the shell does not promote the circulation of the water, or at all events but slowly; so that in getting up steam the top of the boiler becomes hotter than the bottom, from which straining ensues. If in addition to this, the feed water when cold be pumped in at or near the bottom of the boiler, the straining at the transverse seams of rivets is intensified. Possibly the Lancashire boiler is more subject to straining and seam-rending at the bottom of the shell than the Cornish, as there is a greater body of dead water lying there in the Lancashire boiler, in addition to which the rate of combustion per sq. ft. of fire-grate is much more rapid in the Lancashire district than that generally adopted in Cornwall. In consequence of seam rents occurring at the bottom of Lancashire boilers when the last heat is carried underneath, the plan of passing the flame under the bottom immediately on leaving the furnace tubes, and also of introducing the feed water near the surface, has become the general practice. The question of economy is met by the use of feed-water heaters, consisting of a number of water pipes placed in the main flue between the boiler and the chimney, and kept free from soot by an automatic scraper. A good feed heater will raise the temperature of the water to about 240°. This answers two good purposes: it economizes the waste heat escaping to the chimney and thus reduces the coal consumption, while at the same time it prevents local cooling, thereby preventing straining and saving repairs. It has been found by experiment that passing the flames from the furnace tubes around the outer shell, instead of direct to the chimney, adds but little to the yield of steam, though it promotes economy of fuel: at the same time it keeps the boiler at a more equable temperature throughout.

The flooring or hearth plates at the front of the boiler are set so as not to butt against the boiler, which is too often the case, but so as

to be entirely below it, as in Fig. 2, thus leaving the whole of the front end plate open to view. Where there is a range of boilers, these flooring plates extend throughout the width of the boiler house; and being finished off with a fender-flange where abutting against the boundary walls of the building, as well as against the face of the brickwork setting, they present a very neat appearance. These plates are carried on a complete system of framing, and are arranged for easy lifting. The hearth pit beneath them is open from one side of the boiler house to the other, and in this is laid the main feed-pipe, as well as the discharge pipe from the blow-out and scum. This pit is about 3 ft. wide by 2½ ft. deep, so as to afford room for access; the flue doors open into it. The face of the brickwork at the front of the boilers is set back 6 in., so as to leave the angle-iron with its circle of rivets perfectly open. The front cross wall beneath the boiler is recessed around the blow-out elbow-pipe, so that it may be free to move should settlement of the boiler take place.

Boiler Covering.—The boiler is covered with an arch of brickwork, leaving a space of about 2 in. between it and the plates, as in Fig. 3; and a layer of cork shavings or a coating of good boiler-composition or other suitable non-conducting substance is introduced into this space. Openings finished off with bull-nosed bricks are worked round the fittings, so as to leave the ring of rivets by which they are attached to the shell exposed to view. Sometimes the boiler is covered simply with a layer of composition, which should not be carried over the flanges of the fittings, as is too often the case, but should be stopped off by means of curb hoops dropped around the flanges, and a curb cast-iron nosing to guard the front angle-iron.

Connections.—All connections to boilers should be elastic, so as to allow of their movement. If the main steam-pipe be carried across the boilers and bolted direct to the steam junction valve, the joints are strained by the rising and falling of the boilers as they are set to work or laid off. To prevent this, a springing length should be introduced between the steam-stop valve *G*, and the main steam-pipe, as shown in Fig. 1. Where the main steam-pipe has a considerable length to travel to the engine, it should not be taken in a direct line, but should either be carried round the boiler house or be led in a horse-shoe shaped course, to give elasticity; this is better than introducing an expansion joint, which is not reliable. Sometimes expan-

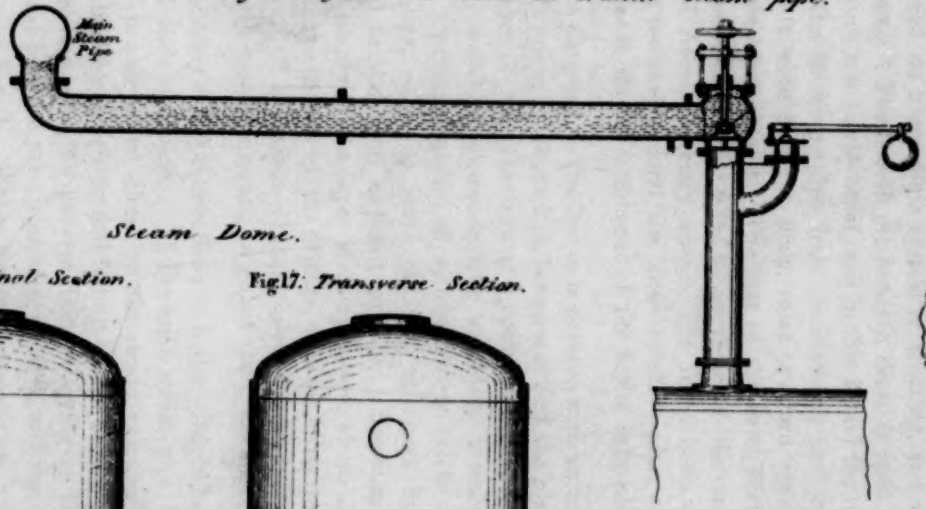


BOILER.

Plate VI

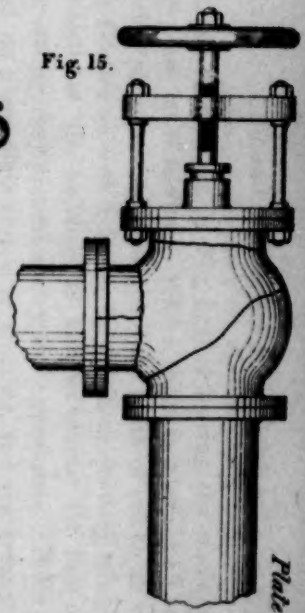
Fractured Junction Valve-Box
through lodgment of water in branch steam pipe.

Fig. 14.



Scale 1/48th

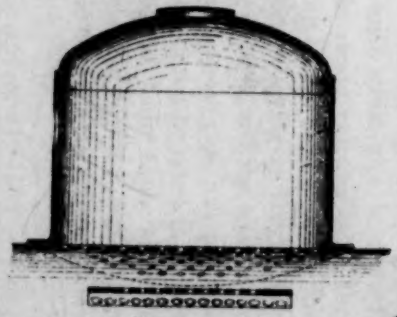
Fig. 15.



Scale 1/16th

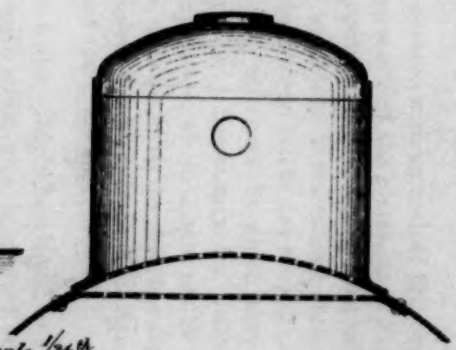
Steam Dome.

Fig. 16. *Longitudinal Section.*



(Proceedings Inst. M.E. 1876)

Fig. 17. *Transverse Section.*



Scale 1/24th

Plate VI

sion diaphragms are adopted; but these when as much as 4 ft. diameter have been known to lead to the fractures they were intended to prevent, the internal pressure causing them to bulge outwards, when it was expected that they would allow the pipes to expand and thrust them inwards. A case of this sort has recently come under the writer's knowledge, in which the main junction valve was broken off by the thrust occasioned by the bulging of the expansion diaphragm. It is equally important that the feed connection should be elastic; and from the want of elasticity, feed valve-boxes have been known to fracture. For this purpose a copper elbow connecting-pipe *P*, Figs. 1 and 2, is introduced between the main feed-pipe and the stand-pipe; in some cases a wrought iron horse-shoe shaped pipe has been adopted instead, with very satisfactory results.

Connections between the steam stop-valve and main steam-pipe are frequently made to incline upwards, as in Fig. 14, Plate IV, so that the water may drain back to the boilers. This plan however is objectionable; for when one of the boilers in a range is laid off, the connecting length becomes filled with water from condensation of the steam, which, cooling by radiation, sets up a violent conflict with the steam, whereby the pipes are sometimes fractured. The action may be illustrated by the commotion which occurs within a locomotive tender when the steam from the boiler is turned into it. Further than this, on opening the steam stop-valve of a boiler that has been laid off, the water lying on the top of the valve, as in Fig. 14, is apt to be carried forward by the rush of steam, like a water hammer and sometimes to burst the pipes. To prevent this the steam-pipe should drain towards the engine, and not towards the boiler, its course being intercepted by a separator fixed as near the engine as convenient. The principle on which these separators act is that of making the steam take a sharp turn, so as to shoot off the water mixed with it into a catch-chamber prepared for the purpose. Many of these separators are now at work; the principle was advocated by Dr. Haycraft of Greenwich, twenty-five years ago.

Additional Particulars.

Weight and Cost.—The weight of such a boiler as has now been described, when 7 ft. diameter, 27 ft. long, and made of plates $\frac{7}{16}$ in. thick, is about 12 tons without fittings; with fittings 15½ tons. The cost at the present time, delivered on the premises of the purchaser

within a few miles of Manchester, and including the attachment of the fittings, is about £425. The plan of buying a boiler at so much per ton, and then the fittings at so much extra, is quite given up in favor of purchasing the whole for one sum.

Heating Surface.—Such a boiler has a heating surface in the external shell of 370 sq. ft.; in the furnace-tubes, without water-pipes, 450 sq. ft.; in the water pipes 30 sq. ft.: making a total of 850 sq. ft. The fire-grate has an area of 33 sq. ft.; this gives for every square foot of fire-grate 26 sq. ft. of heating surface.

In feed-water heaters the surface varies; sixty pipes, each affording a heating surface of about 10 sq. ft., are now frequently introduced per boiler, making a total heating surface of 600 sq. ft., or about three-fourths of that in the boiler.

Working Results.—From 15 to 20 tons of coal in a week of 60 working hours, or from 17 lb. to 23 lb. per sq. ft. of fire-grate per hour may be burnt in such a boiler without distressing it. This may be done without making smoke; all that is needed is to maintain a good thickness of fire, throw on the coal little and often, admit a little air above the bars for a short time after firing, and avoid the use of the rake. The coal may either be spread over the whole surface of the fire or thrown at alternate firings first to one side of the furnace and then to the other, on the "side firing" system introduced by Mr. C. Wye Williams.

A Lancashire boiler experimented on at Wigan, with furnaces 2 ft. 7½ in. diameter and a fire-grate 4 ft. long, evaporated 83·54 cub. ft. of water per hour, from a temperature of 100° Fahr., at the rate of 10·44 lb. of water per lb. of coal, when burning 24 lb. of coal per sq. ft. of fire-grate per hour. With a fire-grate 6 ft. long it evaporated per hour 98·58 cub. ft. of water at the rate of 10·37 lb. of water per lb. of coal, and burnt 19 lb. of coal per sq. ft. of fire-grate per hour. These results were obtained at atmospheric pressure, with the help of a water heater, with good round coal and without making smoke. The boiler described in this paper, having furnaces 2 ft. 9 in. diameter, would evaporate a larger quantity of water per hour. Such a boiler is found in practice to be capable, provided the steam be applied to a fairly economical engine, of developing 200 Ind. h. p., and 20 Ind. h. p. per lineal foot of boiler frontage, side flues included. A Cornish boiler under similar conditions is capable of developing

16 Ind. h. p. per lineal foot of boiler frontage. This leads up to the important question of the utilization of the steam, which the late Mr. Robert Stephenson defined as its "administration," and fuller information is yet needed as to the comparative advantage of working steam on the compound or single-cylinder principle; also as to the value of steam-jackets, as well as with regard to the initial and terminal pressures most conducive to economy. These inquiries, though full of interest, cannot be entered upon in the present paper; but one of the essentials to economy is the power of raising high-pressure steam steadily and safely, and this may be accomplished by the use of the Lancashire boiler.

At least 300 or 400 boilers have been made, of similar construction and equipment to that described in this paper; and among others it may be mentioned that a series of four such boilers can be seen at the Houses of Parliament, employed for heating and ventilating, which were laid down in the year 1869 by Mr. Joseph Clayton of Preston, who was one of the first to assist in carrying out the views of the writer in getting up a first-class boiler equipment for the service of the members of the Manchester Steam Users' Association.

Improvement in Ceramic Manufacture.—M. Faure, a mechanic of Limoges, has invented an attachment to a turning lathe, enabling him to accomplish by machinery the final operation of plate moulding, which has hitherto been done by hand. The appliance gives great uniformity to the work and a large increase of production, turning out an average of fifty pieces per hour. This completes the series of M. Faure's inventions for the manufacture of plates by machinery.—*Soc. d'Encouragement pour l'Industrie nationale*, Dec. 22, 1876; *Les Mondes*, Feb. 15, 1877. C.

Utilizing Solar Heat.—M. Mouchot, by means of conical mirrors, boils coffee, cooks meat, and obtains thermo-electric currents of great energy, from the sun's rays. An opening of four metres square yields a motive force of one-fourth of a horse power. M. Mangon thinks that in Algeria, in the south of France, and in Spain, where there are more than 200 days of utilizable sun-force, the power can be used with as much advantage as the Hollanders and other northern people derive from the wind by means of their windmills.—*Ibid.* C.

ON THE BEST ARRANGEMENT OF CITY STREETS.

[Contribution from the Department of Civil Engineering, Towne Scientific School, University of Penna.]

By Prof. Lewis M. Haupt.

It may be safely assumed *that facility of communication is one of the most potent elements of human progression and development*, hence any obstacle to mobility, however small, becomes a bar to progress, and should, if possible, be removed.

It becomes immediately evident therefore, that the rectangular system of streets is, by itself, defective in consequence of the angles which it opposes to diagonal communications.

Great merit has been awarded Wm. Penn for his prescience in planning this city of Philadelphia, but whilst that plan might answer admirably the requirements of a village, it is very inappropriate to a city of this magnitude. As a matter of history, Penn's letter of instructions to his three commissioners, appointed to execute his designs, will be read with interest.

They were "to seek out a spot on the Delaware River where it is most navigable, high, dry and healthy, where ships may best unload without litering, and where there is good soyle for provisions.

"Having found such a place, lay out ten thousand acres contiguous to it in the best manner you can, as the bounds of said towne; that no more land be laid out until this is taken up; which is the best both for comfort, safety and traffic.

"Be sure to settle the figure of the towne so as the streets may be uniform down to the river.

"Let the place for the store house be on the middle of the key, which will yet serve for market and state house too, only let the house built be as much upon a line as may be.

"The distance of each house from the creek or harbor should be in my judgement a measured quarter of a mile, at least two hundred paces, because of building hereafter streets downward to the harbor.

"Let every house be placed, if the person pleases, in the middle of its platt, as to the breadth way of it so that there may be ground on each side for gardens, orchards or fields, that it may be a greene country towne which will never be burnt, and always be wholesome.

"Given at London, Sept. 15, 1681."

Such was the inception of this, the largest city in area, of the western world. Its growth has far surpassed the most sanguine expectations of its founders, because it combines in its site so many natural advantages. It is readily reached by land or water, its topography is sufficiently undulating to furnish a most perfect system of drainage, with cheap and good water supply, and it has in general a firm and dry soil. Had the original idea of disconnected buildings been adhered to, however, it would always have remained a "greene country towne" of such magnificent distances that but few people could have afforded to live in it. Where would our present population extend to if so domiciled? As concentration and proximity were found to be important elements of defense, intercourse and social and intellectual development, the colonizers soon abandoned the plan and congregated along the river front in both directions until communication became inconvenient, when they began moving along High (now Market) Street towards the Schuylkill.

The rectangular arrangement of streets as proposed being found objectionable, it becomes necessary to examine what other systems, if any, may be used, and determine their relative merits. They may be 1st, *regular*, or 2d, *irregular*, and the first class may be subdivided into rectangular, diagonal and circular; the second into every possible kind of distortion more or less intricate, according to the circumstances attending the growth of a city. All the latter class are discarded as being unscientific, expensive, inconvenient and poorly adapted to the requirements of a growing community.

As people move through a city in every conceivable direction it will be impossible to provide the shortest lines for all, but the case may be met by supposing a greater or less number of centres or *points d'appui*, to and from which the currents of daily life flow and ebb.

With reference to the subdivisions of the first class it is evident that the straight line being the shortest distance between two points the chord will be shorter than its arc and hence the circular system is defective. The rectangular compels a waste of distance and time and the diagonal by itself becomes the rectangular, so that no single system fulfils all possible requirements. A combination must therefore be resorted to, and that composed of right line elements is both the simplest and most direct. A judicious arrangement of diagonal streets with the rectangular system will doubtless be found to meet more fully than any other, the requirements of the case, but it is

evident that if the streets be too wide or too numerous the building areas will be correspondingly decreased and a certain proportion of people forced beyond given limits, thus increasing their distances. On the other hand the diagonals will in general open new building lines, with more than residences enough to provide for all the displaced inhabitants.

To illustrate the utility of such a combination, suppose a portion of a town or city to be laid out in the form of a square whose side is L feet long, and in which the *blocks* are l feet square and the streets w feet wide.

Let the diagonals of the large square be opened as thoroughfares, and note their effect. The *blocks* or small squares extend from the middle of one street to that of its parallel, or from the building line of one block to that of the next, hence the length of a side of such square must be $l + w$ (Fig. 1). The area of the small square, including the streets, multiplied by the number of such squares will give the area L^2 of that portion of the city, and the ratio of street to property area is the same for the small as for the large squares, but the area of the small squares is $(l + w)^2 = l^2 + 2\,lw + w^2$ in which l^2 is the property or building area and $2\,lw + w^2$ is the street area; the ratio being $\frac{2\,lw + w^2}{l^2}$ and *the percentage of street to property area,*

$$\left(\frac{2\,l\,w + w^2}{l^2}\right) 100 \quad . \quad . \quad . \quad . \quad \text{(A)}$$

For *any* rectangle with streets, of unequal widths, the general formula would be:

$$\frac{b\,c + a\,d + b\,d}{a\,c}\,100 \quad . \quad . \quad . \quad . \quad (A^1)$$

in which a and c are the sides of the rectangle, and b and d the widths of the streets. If these quantities are equal, each to each, A^1 becomes A. The number (n^2) of blocks in a given square, whose area is L^2, will be:

$$\frac{L^2}{(l + w)^2} = n^2 \quad . \quad . \quad . \quad . \quad . \quad \text{(B)}$$

If now two diagonals, $\overline{MN}$ and $\overline{PQ}$, be introduced, it is evident that where they cross the rectangular streets no additional area is taken from the private property of the city, but they will cut out of

Fig 2

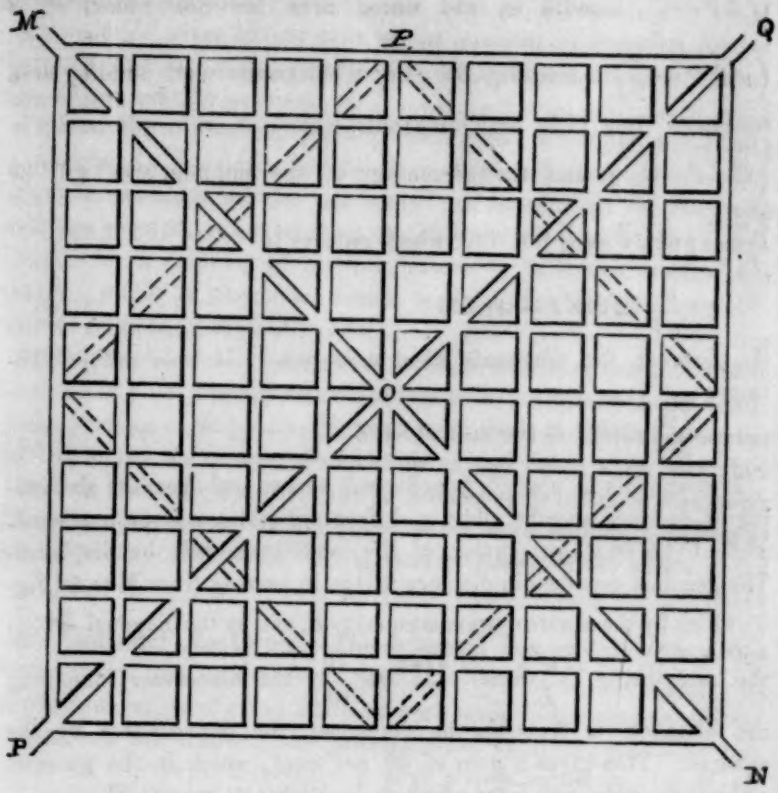


Fig 1

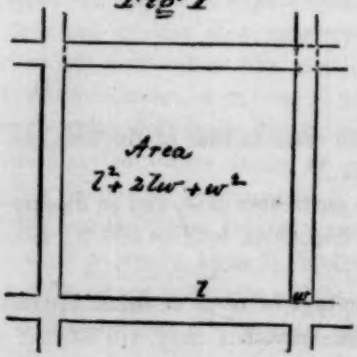
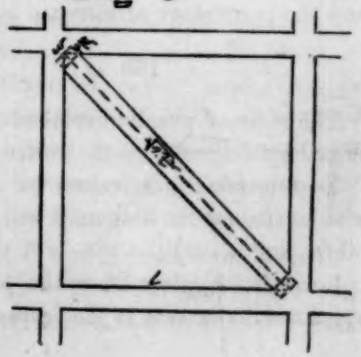


Fig 3



each of the small squares which they cross an area whose length is $\sqrt{2\,l^2} - \frac{w}{2}$, breadth w, and whose area for one block, l^2, is $\left(\sqrt{2\,l^2} - \frac{w}{2}\right) w$ (see Fig. 3). For n blocks the total building area consumed from L^2 by both diagonals, when n is even, will be $2\,n\,w\left(\sqrt{2\,l^2} - \frac{w}{2}\right)$, and the percentage of the building area will be $\frac{2\,n\,w}{n^2\,l^2}\left(\sqrt{2\,l^2} - \frac{w}{2}\right) \times 100$, which reduces to

$$\frac{w}{n\,l^2}\,(2{\cdot}828\,l - w)\,100 \quad . \quad . \quad . \quad . \quad (C)$$

the formula for diagonals when n is even. If *n be odd*, *C* becomes:

$$\frac{w}{n\,l^2}\,(2{\cdot}828\,l)\,100 = 282{\cdot}8426\,\frac{w}{n\,l} \quad . \quad . \quad (C^1)$$

If diagonals be opened, benefits will accrue both from the shortening of distance and the additional frontage which will be furnished, while but a small proportion of the inhabitants will be displaced. The greatest economy in distance will be in passing from *M* to *O* (Fig. 3), which by the square system is equal to L, and by the diagonal $L\sqrt{\frac{1}{2}}$, the ratio being $\frac{L\sqrt{\frac{1}{2}}}{L} = \frac{1{\cdot}4142}{2} = \frac{70}{100}$, the numerator indicating the distance (in feet) by the diagonals, the denominator by the squares. This gives a gain of 30 per cent., which is the greatest amount possible, and from which it diminishes to zero at *P*.

The total length of *frontage* on the streets in the square system is $4\,l\,n^2$. The diagonals give an additional length of $4\,n\,(\sqrt{2\,l^2} - w)$, and the percentage of increase is, therefore:

$$\frac{l\sqrt{2} - w}{l\,n}\,100 \quad . \quad . \quad . \quad . \quad . \quad (D)$$

The ratio of people displaced is the same as that of the area consumed by diagonals to the entire area L^2.

To determine these values for any particular case, and so discover whether or not the diagonals will be beneficial, let $l = 500$ ft., $w = 50$ ft., and $n = 10$.

Formula (A) gives 21 as the percentage of *large or small* squares consumed by streets in the rectangular system.

Formula (C) gives only 2·82 per cent. of additional building area consumed by diagonals.

Formula (D) gives 13 per cent. as the increase in frontage due to diagonals, and it has been shown that the saving of distance varies from 30 per cent. to nothing.

The number of people displaced, which is but 2·82 per cent., will be abundantly provided for by the additional frontage on the diagonals, revenues will be augmented by assessments on the new buildings erected, and a large saving will be effected in time and distance for a majority of the inhabitants by this combination of systems, which is therefore found to fulfil the requirements of practice more fully than any other.

Similar applications of the above formulæ will show to what extent the plans of cities already established or to be built, may be improved by the opening of diagonals, the most economical relation of street to building area, the proper distribution of the street area, and, by extending the analysis, the ratio of pavement to carriage way may also be readily determined. All of these questions have a direct bearing on the convenience, health, and extension of our cities.

St. Gothard Railway.—The estimated cost of this enterprise when it was first undertaken, was 187,000,000 fr. It has been found, however, that grave mistakes were made in the original calculations, and M. Hellwag, the present chief engineer, states in his report to the Swiss Government, that an additional capital of at least 102,000,000 fr. will be required in order to finish the work. The original estimates were based upon maps on a scale of 1 : 10,000, and did not make sufficient allowance for the protection which would be required against mountain torrents, avalanches, land-slides, falling rocks, and other like contingencies. In consequence of this serious miscalculation the works are suspended, except in the grand tunnel, which has been driven to more than half its length. The decision as to future action is complicated by political questions, arising from the subventions of the German and Italian governments; but the Swiss federal council has appointed a commission of engineers to report upon M. Hellwag's propositions, and it is hoped that satisfactory measures will be devised for carrying them out.—*Annales des Ponts et Chaussées*, Jan., 1877. C.

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By Francis E. Galloupe, S. B.

[Continued from Vol. ciii, page 173.]

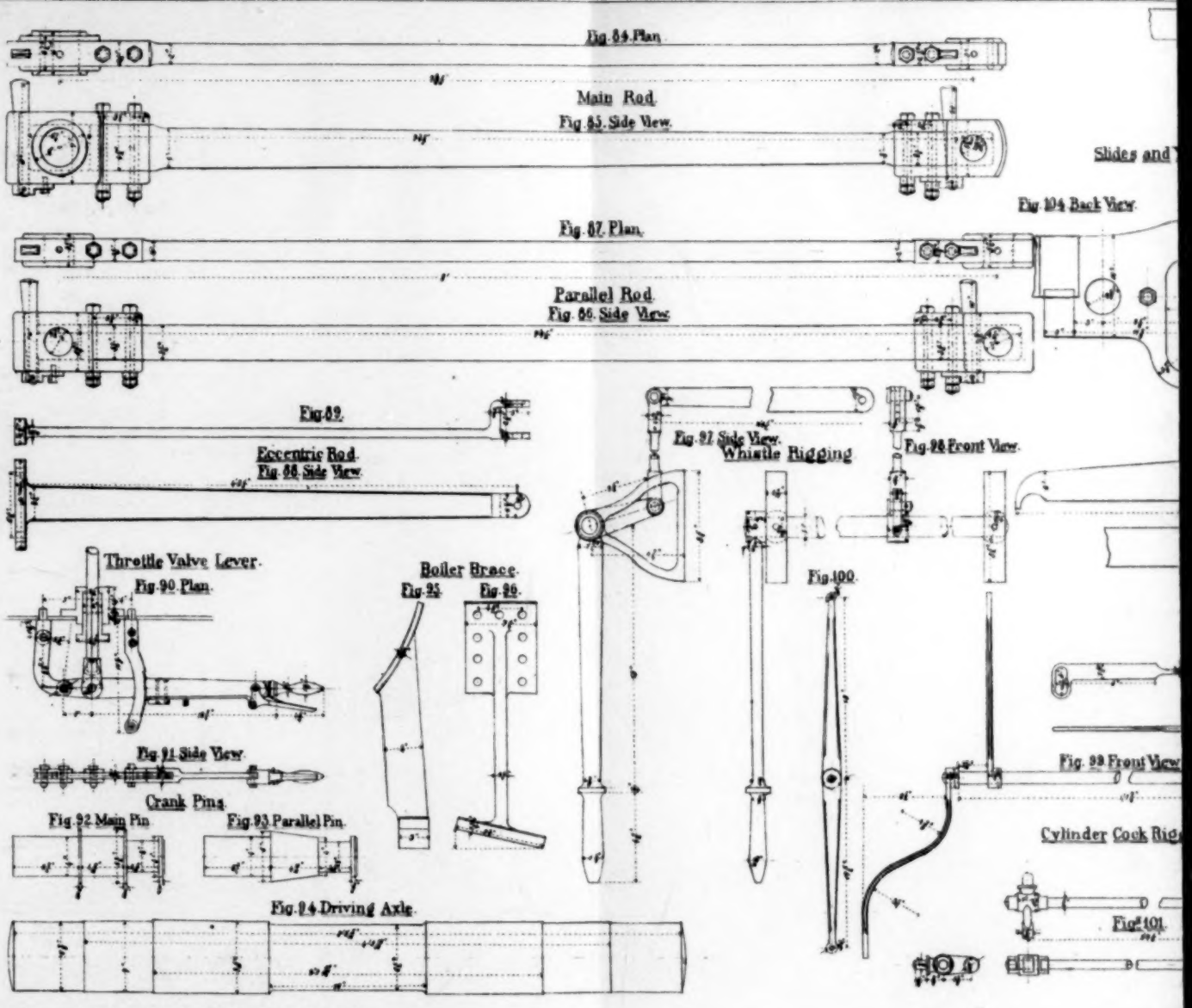
It should be said that hardly any of the data will be found to be exact. For, first, since they were wholly taken by one person, where several things had to be observed at once, such as the time, the speed, and the steam pressure, a difference in the time of taking the three, with the accompanying changing conditions, was necessarily perceptible; and, second, no more exact methods of taking the data, such as the use of appliances for making a test, scales, measuring tanks, speed recorders and dynamometers, the use of all of which, with the addition of indicator diagrams taken from the cylinders, would of course be preferable and which it would have given me great pleasure to have attempted, could be employed, on account of the interference they would have caused with the duties of the engineer in the running of the engine. The memoranda are therefore observations only, which could be made in the cab, and do not represent experiments, and it is only from the lack of such data from American engines that I cause them to occupy so prominent a place in my discussion by inserting the records in full.

Precisely what the columns of these tables represent will now be stated.

Column 1. *Miles to or from Boston.*—These distances were obtained from the published time table of the Eastern Road. Considering that these were not strictly accurate, application was made to the chief engineer of the road for a profile map by which the distances could be obtained with greater accuracy, and also the grades at any points of the road at which the speed was taken. Being disappointed in this, for the reason that no regular survey of the road has been made since its construction, I was obliged to take the time table distances as a basis, and remedy the inaccuracies, as well as I could, from personal knowledge of the road.

Columns 2 and 3 require no explanation, further than to say that where the times are given, in column 2, a stop was made, and there

DETAILS OF PASSENGER ENGINE BY HINKLEY LOCOMOTIVE WORKS.



Weissenborn's "American Locomotive Engineering."

F PASSENGER ENGINE BY HINKLEY LOCOMOTIVE WORKS.

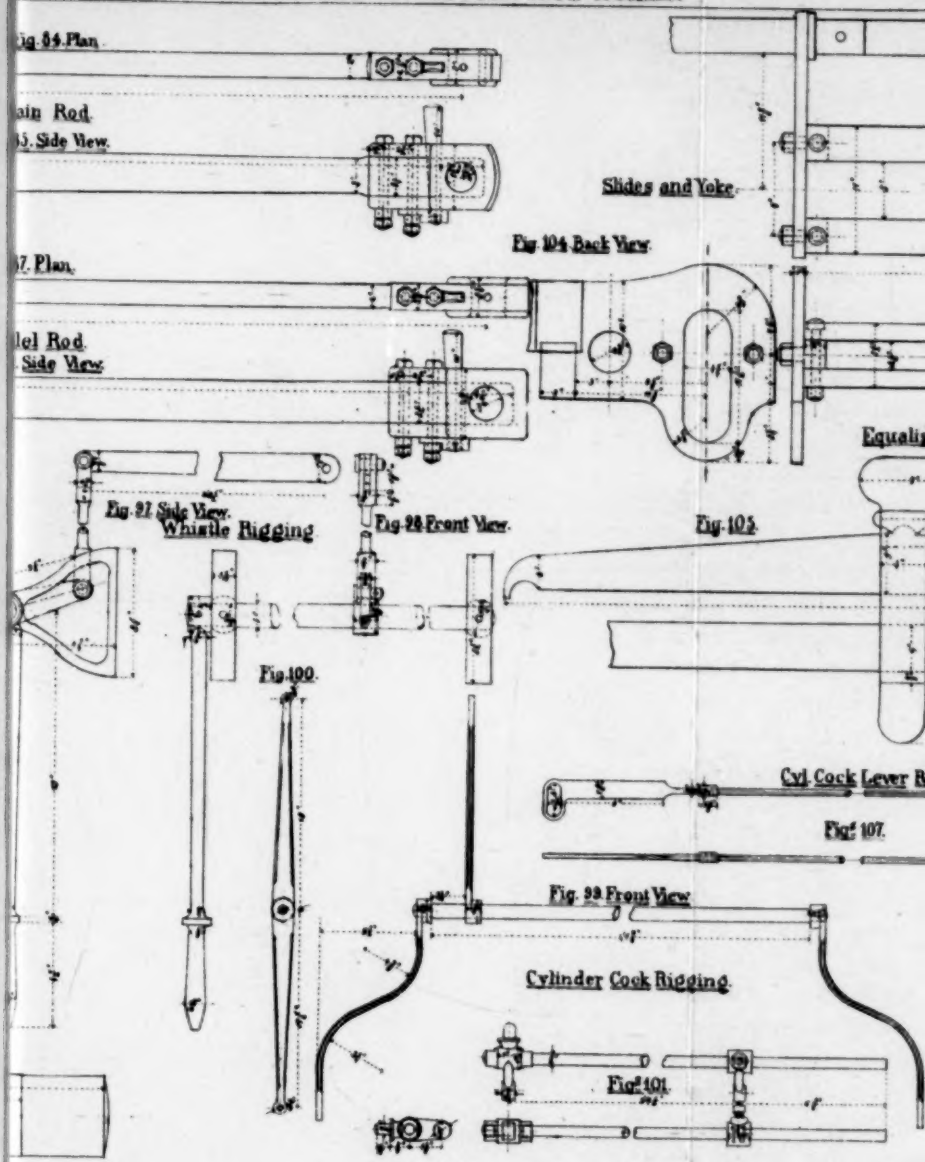


Plate C.

Fig 102. Plan.

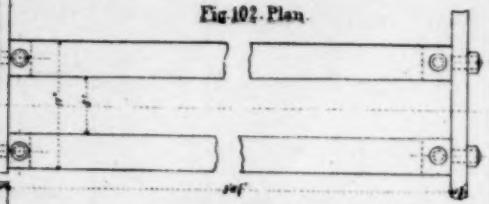
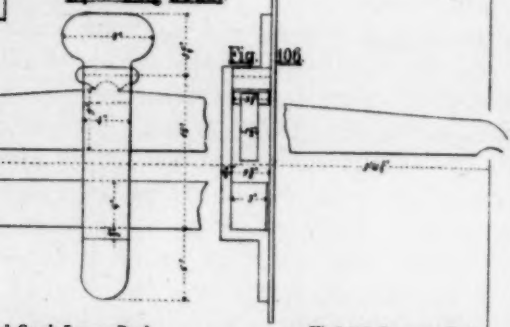


Fig 103. Side View.

Equalizing Beam.

Fig. 106.



d Cock Lever Rod.

Fig. 107.

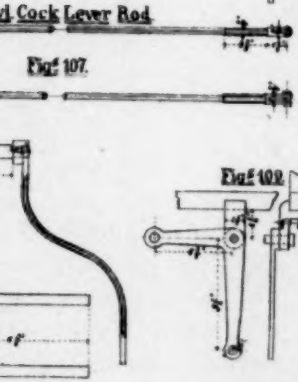


Fig. 108. Damper Rod.

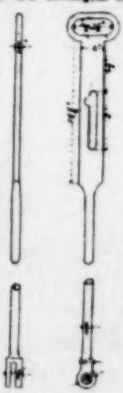
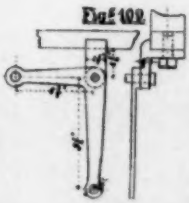


Fig. 109.



Francis E. Gallonde.

were no others except where indicated in column 5, which shows the number made on each trip.

Column 4. *Train Arrivals and Departures; Corrected Time by Watch.*—These were noted by the second hand of the watch at the instant of full stop and starting. Where two times are given opposite the name of one station, the upper one signifies the stop, the lower one the start, and opposite in column 6, are the steam pressures at those instants.

Although the watch used had been just previously regulated, the jar of the engine influenced its rate, and I have thought it well to apply a correction to the times in order to insure greater accuracy in the results involving their use, in the other columns. This was done by the following method.

From Tables I and II, on Wednesday, March 15, it will be seen that it was noted at Boston before leaving that the watch had been set by the depot clock, which gives correct Cambridge time, so as practically to agree with it at 8.30 A. M., and it is also noted that on the return to Boston the watch was 15 seconds fast by the clock at 1.55 P. M. Let the horizontal line, *A B*, represent this duration of time, in the accompanying diagram. The length of this line represents the interval (12 M. — 8.30) + 1.55 = 5 hours, 25 minutes. At the end of this interval the watch was 15 seconds fast, and this is represented by the ordinate or positive distance, *B C*, above the line *A B*. Now at the beginning, or at 8.30 A. M. the watch coincided with the clock; hence by drawing the diagonal line *A C*, we represent the gain of the watch by the length of the ordinate at any point, *on the assumption that the rate was the same, or that this gain was uniform*, during the whole interval. To obtain the true time, we must therefore subtract from the indication of the watch at any time, a number of seconds represented by the length of the ordinate at the same point.

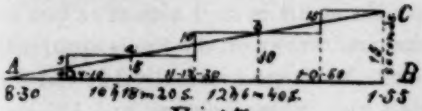


Fig. 7.

Now, I have taken the limit of error for the time, at 5 seconds, and hence at the point $a = A\,B \div 3$ we have the interval 5 h. 25 m. $\div$ 3 = 1 h. 48 m. 20 s., which added to 8 h. 30 m., gives the time, 10 h. 18 m. 20 s., at which the watch is just 5 seconds too fast. And at 1 h. 48 m. 20 secs. more or 12 h. 6 m. 40 secs., it is just 10 seconds too fast. Now at points half way between these it is assumed that the watch

jumps in its indications 5 seconds, as shown by the jogged line, and continues for an equal distance on either side of the points *A*, *a*, *b*, and *C*, which give the true times of this increase. So that no correction is made, in this case, from 8.30 to 9.24, when 5 seconds are subtracted from all the readings till 11.13, when 10 seconds are subtracted, etc., and similar corrections were made for the other tables.[1]

Column 6. *Steam Pressure,—Gauge Readings.*—The gauge upon this engine was of the American Steam Gauge Company's make, a Bourdon Gauge with Lane's Improvement, and similar in all respects to that described and illustrated in Part I. The readings were taken as soon as possible after noting the times, and vary from three, five, to ten seconds only, behind time. It has been noticed since the readings were taken that with no steam raised in the boiler, the gauge hand indicated 6 or 8 lbs., but this is perhaps not unusual in locomotive gauges on account of the very stiff springs employed, to prevent the jarring of the engine from making the motion of the hand unsteady. In this column is seen the great and often sudden variations of pressure occurring in locomotives, it hardly remaining the same for two consecutive seconds. Where the steam is used almost as fast as generated, its sensitiveness to the coal thrown on the fire is apparent. The pressures used on the Eastern Road are nominally 140 lbs. for first class engines, to which class this engine belongs, and 120 lbs. for second class, the class of any engine depending upon the length of time the locomotive has been in service. The safety valves were set, one to blow off at 130 lbs., and the other at 135, and, in the tables, the variations from these pressures are seen. In several instances, the pressure rose to 144 lbs., and in one, the valve began to rise at 144½ lbs. (Table III), in another case in the same table closing at 133 lbs. In Table II, the pressure at Salem, rose 19 lbs. in 1 minute, 25 seconds.

From the averages for each trip of 56 miles we notice the difference produced in the steam pressure by the weather. On Wednesday, there being a strong wind, the average is lower for the return trip, as the wind was West and against the train; on the second day, it is about the same both ways, or 131 and 133 lbs. (Tables III and IV), and much higher than on the preceding day when it was 127 and 115 lbs.; and on the third day, it was 132 lbs. down, and but 119

[1] This method is similar to that followed in working up the results of a pumping engine test, at Providence, R. I., Dec., 1875.

TABLE IV.—Trip No. 4.

DATA AND RESULTS FROM HINKLEY ENGINE No. 55, EASTERN R. R., ON BANGOR TRAIN, RETURN TRIP.

Date: Thursday, March 16th, 1876.
Day: Weather, dry and pleasant.—Wind, W., breeze.

At Portsmouth:—Coal taken on, 2 tubs, @ 400 lbs., = 800 lbs. Depth Water in Tender at starting, 42 inches. Number of Cars, 6.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Miles from Portsmouth.	Train Due. Time.	Station.	Time Record.		Steam Pressure. Gauge Readings.	Coal Record.			Speed Record.						Water and Steam Record.		Notes.
	H. M.	Leave	Train Arrivals and Leavings. Corrected time by watch.	Length of Stop.		Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
			H. M S.	M. S.	LBS.	LBS.	LBS.			LBS.						LBS.	
	A. M.		A. M.														At Portsmouth, estimated coal in tender, before taking coal aboard, 6¼ tubs † Safety valve blowing.
	11 18	Portsmouth	11 22 45		137†	189 0	189 0		6	123	250	4090	46 5†		25 515		† Time, 11 29 00. Oil'd cylind's.
			ar. 33 55						6	120	180	2945	33 5†	26·3		318·4	† Time, 11 31.00. Stirred fire.
5	11 28	*Greenland	11 34 10	15	130	108 0	297 0	22	6	118	180	2945	33 5†		14 580		† Up-grade. Time, 11.32 00.
			ar. 39 45						10	117	150	2454	27 9†	19·5		454·9	† Up-grade. Time, 11.36.00. Stirred fire.
7	11 35	North Hampton	11 40 20	35	127	54 0	351 0	22	6	114	210	3437	39 1†		7 290		† At bridge. Time, 11 37.30.
			... ...						10	1?4	90	1472	16 7†	27·3		151·6	† Heavy up-grade. Time, 11.42.00.
10	11 42	Hampton	11 46 55	...	133	54 0	405·0	18	10	130	220	3600	40 9†		7·290		† Time, 11.44.00. At 33.10.
									10	123	250	4090	46 5†	39·1		151 6	† Time, 11.45.00.
13	11 47	*Hampton Falls	11 51 30		129	108 0	513·0	18							14·580		
														12·0		909 8	
14	11 50	*Seabrook	11 56 30		138	108 0	621·0	108	10	133	180	2945	33 5†		14·580		† Up-grade. Time, 11.58.00.
			P. M.						6	130	220	3600	40 9†	29 3		303 3	† Level. Time, 12 00 M.
17	P. M.	*Salisbury	12 02 40		125	40 5	661·5	36	6	127	260	4255	48 4†		5·468		† Time, 12.01.00.
			... ...											30 0		170 6	At Newburyport, depth water in tender, 30¾ in. when still.
19	12 05	Newburyport	12 06 40	...	137†	27 0	688 5	20	10						3 645		† Valve blowing. Taken at 12.09 50
			....														Oiled cylinders.
		Know-nothing	... ...	...	134	54 0	742 5	27	10					17·3	7·290	227·4	Stirred fire.
22		*Knight's Crossing	12 17 05		133	128 3	870 8	32	6						17·321		
			....						6	129	200	3273	37 2†	37·9		270·2	† Up-grade. Time, 12.19.00.
26		*Rowley	12 23 25	...	134	135 0	1005 8	45	10						18·225		Stirred fire. Made a stop.
			ar. 29 45						10	129	200	3273	37 2†	28·3		379 1	† Time, 12.26.00.
29	12 28	Ipswich	12 36 10	6 25	139	243 0	1248 8								35 235		[full. At Ipswich: Depth water, before filling, 24½ in.; after filling,
			ar. 46 00						10	130	220	3600	40 9†	28·8		439·7	† Time, 12.41.00. Second valve blew off at 144 lbs.
34	12 40	Wenham	12 46 35	35	134	54·0	1302 8	49	10	129	220	3600	40 9†		7·830		† Time, 12.42.00.
									10	122	220	3600	40 9†	32 7		244·3	† Up-grade. Time, 12.49.00.
36		*North Beverly	12 50 15		117	40 5	1343 3	27	10	118	210	3437	39 1†		5·873		† Time, 12.50.00.
			ar. 54 45						6	126	200	4745	53 9†	26 7		183·2	† Down-grade of 43 ft. to a mile. Time, 12.53.00.
38	12 48	Beverly	12 55 45	1 00	138	40 5	1383 8	20	10						5·873		
			....								200	3273	37·2†				† Speed taken while slowing down. Time, 12.58.00.
		Know-nothing	12 59 15	...	136	27 0	1410·8		10					18·5	3 915	305·4	Stirred fire.
			ar. 02 15														At Salem, depth water, 33¼ in.
40	12 58	Salem	1 05 15	3 00	141	108 0	1518 8	34	10	134	180	2945	33 5†		15·660		† Time, 1.08.00.
44		Swampscott	1 12 20			27 0	1545·8	27	10	136	200	3273	37 2†	33·9		244·3	† Time, 1.09.00.
			ar. 14 40		146				6						3·915		
45	1 11	Lynn	1 16 10	1 30	143	13 5	1559·3	27						25·7	1·958	244·3	
														24·0		122·2	
46		West Lynn	1 18 40			67 5	1626·8	14	10	132	200	3273	37 2†		9·788		† At long bridge. Time, as corrected, 1.20.20.
		Oak Island	1 24 15		126	40·5	1667·3		6	125	200	3273	37 2†				† At bridge. Time, 1.22.00.
									6					31·6	5·873	244·3	
50		Revere	1 26 15		124	81·0	1748·3	27	6	124	200	3273	37·2†				† Time, 1.24.00.
			ar. 29 25						6						11·745		Stirred fire.
51	1 28	Chelsea	1 30 05	40	134	27 0	1775·3	81	6	119	200	3273	37·2†	18·9		732·9	† Time, 1.27.00.
															3·915		Stirred fire.
53		Everett	1 33 30		122				10					34·9		122·2	
									6								
		Curve at Somerville	1 35 10		131				6	134	240	3927	44·6†				† Corrected time, 1.33.50.
			ar. 35 35						6					28·8			
54		Somerville	1 37 50	2 15	142	54·0	1829·3	9	14						7·830		Stirred fire.
																	Oiled cylinders
		B. & M. R. R. Crossing															
			....														
		Prison Point	1 41 10	...	133	40·5	1869·8										
							Tot. for 56 miles run.							26·1	5·873	427·6	
		Arrive at															
56	1 45	Boston	1 42 25				Av. lb. coal per mile, 34	52									Watch 20 secs. slow at 1.45 P. M. Depth of water in tender on arrival, 26 inches.
			Average steam pressure, 133 lb.										Average,	27·2	Average,	316·5	

*Flag Stations.

TABLE V.—Trip No. 5.

DATA AND RESULTS FROM HINKLEY ENGINE, No. 55, EASTERN R. R., ON 8.30 A. M. BANGOR TRAIN, DOWN TRIP.

Date: Friday, March 17th, 1876.
Day: Weather, sleety; rain, wet, icy and slippery; Wind, E.

At Boston: Coal in Tender at starting, tender full, estimated, 15 tubs @ 400 lbs. = 6000 lbs.
Depth Water in Tender at starting, 41 inches.
Number of Cars, 8, same as on Wednesday.

1	2	3	4			5		6	7	8	9	10	11	12	13	14	15	16	17	18
			Time Record.						Coal Record.			Speed Record.						Water and Steam Record.		
Miles from Boston.	Train Due. Time.	Station.	Train Arrivals and Leavings. Corrected time by watch.			Length of Stop.		Steam Pressure. Gauge Readings.	Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	Notes.
	H. M.	Leave	H.	M.	S.	M.	S.	Lbs.	Lbs.	Lbs.			Lbs.						Lbs.	Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
	A. M.		A. M.																	
	8 30	Boston	8	31	20			134	54·0	54·0								4·158		Watch 10 seconds slow at 8.28 A.M.
		Prison Point	8	34	00	...		133	81·0	135·0							18·2	6·237	389·2	Oiled cylinders.
		B. & M. R. R. Crossing	8	36	35	...		142½†	27·0	162·0								2·079		† Valve blowing.
2		Somerville	8	37	55			142	67·5	229·5		10						5·198		
		Curve at Somerville	8	39	10			141	54·0	283·5	115	10					18·0	4·158	583·8	
3		Everett	8	41	15			131	94·5	378·0	54	10	132	220	3000	40·9†		7·277		† Time, 8.40.00.
												10	127	270	4418	50·2†	32·7		227·0	† Time, 8.42.00.
5	8 42	Chelsea	8	44	35	..		140†	67·5	445·5	47	10						5·198		Stirred fire.
												10	125	180	2945	33·5†	15·0		324·4	† Time, 8.47.00.
6		Revere	8	48	35			136	67·5	513·0	68	10						5·198		† Valve blowing.
												10	127⅛	240	3927	44·6†				† Time, 8.50.00.
		Oak Island	8	51	15			127	67·5	580·5							37·5	5·198	162·2	
												10	124	240	3927	44·6†				† Time, 8.53.00. At end of taking speed were at long bridge.
10		West Lynn	8	55	00			119	.....		34	10						.....	.....	Stopped from full speed in 1 min. 10 secs.
			ar.	56	45			.....									34·3			
11	8 59	Lynn	8	59	30	2	45	139†	148·0	728·5	00	14						11·396		Stirred fire.
																	16·4		711·1	
12		Swampscott	9	03	10			114	148·0	876·5	148	10						11·396		† Valve began to blow at 144 lbs., and was still
			ar.	09	50			124				10	102	190	3108	35·3†	36·0		177·8	† Time, 9.5.00. [blowing at 139 lbs. at starting.
16	9 12	Salem	9	12	30	2	40	140	81·0	957·5	37	10	102	200	3273	37·2†		6·237		† Time, 9.5.30. At Salem, oiled cylinders and
		Know-nothing				...		134	81·0	1038·5		10					17·3	6·237	389·2	At 9 7.40, shut off by throttle. [engine outside. At 9 7.44, reverse rod put forward.
			ar.	19	25			131												At 9 7.50, brake put on.
18	9 25	Beverly	9	20	10		45	137†	162·0	1200·5	81	10						12·474		† Valve blowing. Stirred fire.
			ar.	26	40			.....				10	121	160	2618	29·8†	18·5		389·2	† Heavy up-grade, time, 9.22.00.
20	9 26	*North Beverly	9	27	00		20	124	108·0	1308·5	81	17						8·316		Stirred fire.
			ar.	31	35			.....				10	118	184	3010	34·2†	26·1		259·5	† A long and heavy up-grade, time, 9.27.00.
22	9 32	Wenham	9	32	10		35	139	222·8	1531·3	54	14						17·156		
			ar.	41	30			133				10	128	260	4255	48·4†	32·1		214·0	† Time, 9.37.00.
27	9 43	Ipswich	9	44	10	2	40	133	202·5	1733·8	46	6	120	230	3764	42·8†		20·756		† Time, 9.39.00.
												10	109	260	4255	48·4†	22·1		431·7	† Time, 9.50.00.
30	9 50	*Rowley	9	52	20			134	87·8	1821·6	68	10						9·000		
												10	107	190	3108	35·3†	33·9		140·4	† Up-grade, time, 9.56.00.
34		*Knight's Crossing	9	59	25			100	94·5	1916·1	22	10						9·686		Stirred fire.
								.....												Stirred fire.
		Know-nothing	10	03	00	...		117	128·3	2044·4							23·6	13·151	475·0	
			ar.	07	00			.....												At Newburyport, depth water in tender, 34¾ inches.
37	10 05	Newburyport	10	09	20	2	20	138	148·5	2192·9	74	10						15·221		
												10	121	230	3764	42·8†	26·7		474·9	† Time, 10.13.00.
39		*Salisbury	10	13	50			119	121·5	2314·4	72	10						12·454		Stirred fire.
			ar.	20	00			.....				10	110	160	2618	29·8†	29·2		250·0	† Heavy up-grade, time, 10.17.00.
42	10 20	*Seabrook	10	20	25		25	124	175·5	2489·9	41						14·1	17·989	1091·0	Opened back ash pan damper.
43	10 25	*Hampton Falls	10	24	40			138†	108·0	2597·9	176	6	125	110	1800	20·5†		11·070		† Valve blowing. Stirred fire.
			ar.	30	15			.....				21⅛					20·9		230·3	† Very heavy up-grade, time, 10.29.30.
46	10 33	Hampton	10	32	00	1	45	141	162·0	2759·9	36	17						16·605		
			ar.	39	05			.....				14	132	96	1571	17·9†	25·3		345·4	† Time, 10.34.30.
49	10 40	North Hampton	10	39	45		40	138	108·0	2867·9	54	10						11·070		Oiled cylinders. Stirred fire.
												10	124	170	2781	31·6†	19·5		345·4	† Speed taken at stone overhead bridge, time,
51	10 47	*Greenland	10	45	55			141†	189·0	3056·9	54	10						19·373		† Valve blowing. [10.43.00.
										Tot. for 56 miles run.										Oiled cylinders. Stirred fire.
		Arrive at																		
56	10 57	Portsmouth	10	56	40			125			38	10	118	200	3273	37·2†	27·9		241·8	† Down-grade, time, 10.50.00.
												10	117	110	1800	20·5†				† Time, 10 55.15, and taken for ¼ minute. Bent draw pin.
		Average steam pressure, 132 lbs.							Av. lb. coal per mile,		64		Average,				24·8	Average,	374·4	At Portsmouth { Depth water before filling, 21 ins. Depth water after filling, 41½ ins.

* Flag Stations.

on the return trip, the wind, as we see, affecting it very much on the exposed portions of the road.

Column 7. *Coal Record; Weight fired between Stations.*—This was found in what may be considered, perhaps, a very rough manner. The times of firing between every two stations, were noted, in number, and the equivalent number of full shovels of coal thrown in at each time estimated. That is, the fireman would throw in from one to three shovelfuls at a time, and then, in perhaps half a minute more, two more, etc., and whether these amounted to 1½ or 2 *full* shovels, was estimated and noted, and after a little practice this could be done quite accurately. We see also that the relative quantities thrown in at different parts of the road are known, if not the absolute, for practically the firing was quite even.

The shovel, full of coal, was weighed on scales before starting, the coal was in the same condition as to dampness as when used on the road, and the record reads:—

Weight of the shovel *full* of coal, . .	21 lbs.
" " empty, . . .	7½ "
Weight of coal contained in one shovelful,	13½ lbs.

The coal record was obtained, using this number, which was verified by several weighings.

Column 8, the *Aggregate Weight* of coal fired, shows the great variation in the amount burned in doing the same work on consecutive days. The differences in the conditions were those of the wind and weather. On Wednesday, during the down trip, nearly half a ton more coal was burned, than on Thursday, and on Friday, 1133 lbs. more. We had the same fireman on Wednesday and Friday, but a different one on Thursday. Whether the predominating influence was that of the wind or the fireman, is a question I do not attempt to decide.

Column 9 shows the same variation.

Column 10. *Cut-off.*—This column is intended to give a general idea only, of the point at which the steam was cut off in the cylinder. The reverse quadrant had its notches marked as given in Fig. 114, Plate D.

Columns 12, 13 and 14. *Speed Observed.*—This was obtained by counting the number of revolutions made by the driving wheels in one-half minute, and multiplying this by two we obtain the number of

revolutions per minute shown in column 12. In taking the speed a full minute was not used on account of the liability of losing the count, and because of the fact that the speed was constantly changing and also the character of the road. It was the intention to take the maximum speed at least once between each two stations. This was done as follows.

When it was thought that the engine was at its maximum speed the time was noted, about ten seconds before an even minute. A straight piece of track was also selected, or, sometimes, a heavy grade. Precisely on the even minute, watch in hand, the counting was commenced, and after a little practice, the watch could be glanced at to see whether the time was out or not, and the counting continued mentally without missing a count. At the end, the number was set down, then the steam pressure, as quickly as it could be read, the number of the cut-off notch, and any remark, if taken on an exceptional grade.

The feet traveled per minute, column 13, were found by multiplying the number of revolutions by the circumference of the driving wheels, viz., $2\pi r = \pi d = 3{\cdot}1416 \times 62{\cdot}5 = 16{\cdot}36$ feet, and the rate in miles per hour, column 14, by multiplying the feet traveled per minute by 60, to obtain the feet per hour, and dividing by 5280, the number of feet in a mile.

Column 15. *Average Speed between Stations.*—In computing this, the difference of the times was taken, reduced to seconds, divided by the number of miles between the stations, which gave the number of seconds in which one mile was run; and 3600, the number of seconds in an hour divided by it, which gave the average rate in miles per hour. Where the time of stopping was noted, that is taken in computing the average speed, and hence the total averages per trip will be found to exceed that calculated from the time of the whole trip.

The highest average speed during any of the trips (throwing aside that in Table I, which is doubtful) is that between Hampton and Hampton Falls, a distance of 3 miles, on Thursday (Table IV), when 39·1 miles per hour were attained. This was on a heavy down grade, as the other tables show, of 43 feet to the mile.

In the column of maximum rates there are three that indicate a speed of over 50 miles per hour,—50·2 miles (Table V), 53·9 (Table IV), and 67·0 (Table VI). The last rate being so exceptional, the circumstances attending it may be mentioned. The track was that

portion between North Beverly and Beverly, which has a down grade of about 40 feet to the mile, the cut-off was at 6 inches of the stroke, and the throttle wide open. It will be noticed that 360 revolutions in a minute, or 90 in one-fourth minute, is about as fast as a person can count. In fact this, equal to six times per second, could not have been audibly counted, but was partly estimated. The number of turns could be estimated by the eye when, perhaps, they could not be counted, and the high speed obtained immediately afterward which serves as a check, leaves no doubt, I think, that this speed was actually realized. It was calculated as follows: $16{\cdot}36 \times 360 = 5889{\cdot}6$ feet per minute. To this, as the speed was over 200 revs., 1 foot is to be added to make up for decimal places omitted, viz., 16·3625. Therefore, $5889{\cdot}6 + 1 = 5891$, which multiplied by 60 gives 353,760 as the feet per hour, and dividing this by 5280 we obtain 67 miles per hour. In all calculations in this thesis, it may be mentioned, that whenever the rejected decimal places were one-half, ·5, or over that of the next figure preceding, the next larger number has been invariably taken.

Columns 16 and 17. *Water and Steam Record.*—The datum taken by which this has been obtained was the depth of water in the tender at several points along the road. This was obtained, on the first day, by inserting the handle of the fireman's broom into the manhole of the tender and then measuring the length of the part wet. Afterwards a notched stick, graduated to quarters of inches, was used, with an increase of accuracy.

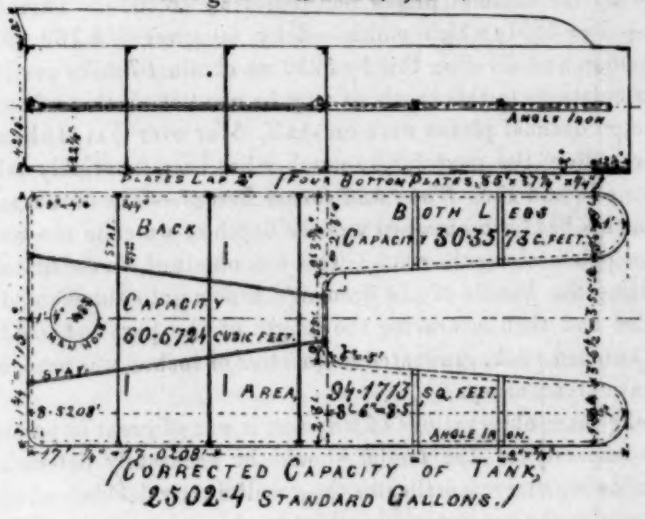
To make these observations of any use, it was of great importance that the capacity of the tender should be accurately determined.

The following diagram indicates the result finally determined upon, and shows also the construction and internal bracing of the tank.

The tender of this engine is of unusual length and capacity; the tank, nominally of 2500 gallons capacity, being nearly a foot longer than the ordinary tank of 2000 gallons. To obtain its capacity with the greater accuracy, the working drawings were used, access being had to them at the Hinkley Works, and *in addition*, actual measurements were taken with a steel tape of every accessible part. These, the more important of which were repeated several times, have been mainly followed in calculating its capacity, and those upon the drawings have served rather as checks. The area of the back was found to be 60·8551 sq. ft., as follows:—area back = area rectangle, $8{\cdot}5208$ ft. $\times$ 7·15 ft., diminished by the difference between the areas of a quad-

rant of a circle of a radius, $r = \cdot 4$ ft., at corners, and of a square of $\cdot 4$ ft. side $= 60 \cdot 9237$ sq. ft. $- 2\,[(\cdot 4 \times \cdot 4$ ft.$) - \frac{1}{4}\pi r^2] = 60 \cdot 9237$ sq. ft. $- 2\,(\cdot 16$ sq. ft. $- \cdot 1257$ sq. ft.$) = 60 \cdot 8551$ sq. ft. In the same manner the area of the other parts was found, correcting for the curved portions. Multiplying by the height, $42\frac{7}{8}$ inches $= 3 \cdot 572$ ft., the gross number of cubic feet in the tank was found to be $336 \cdot 3799$. According to Haswell's Engineer's Pocket Book, "the standard gallon equals 231 cubic inches, and contains 8·33888 lbs. of distilled water, at its maximum density, 39·1° Fahr., the barometer being at

TANK OF HINKLEY ENGINE No. 55, E.R.R.
Fig. 8 — SCALE. 3/16" = 1'.



30 inches." Hence there are $\frac{1728}{231} = 7 \cdot 4805$ gallons in a cubic foot. Multiplying our result by this, the gross capacity of the tank is 2516·2898 gallons.

(To be continued.)

The Electric Light Apparatus.—The work of fitting the electric light apparatus on board the *Alexandra* is now complete. By means of this light (on the mizzen mast), it is stated that when at sea very small objects will be distinguishable some two or three miles distant.—*Telegraphic Journal.*

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* By measurement.

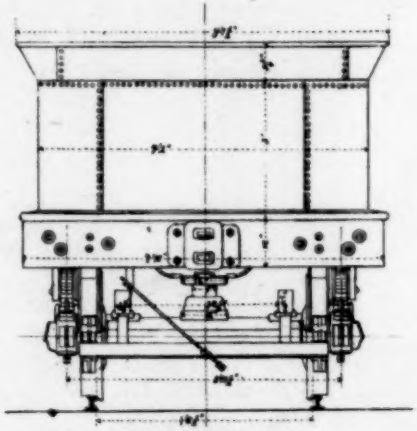

Fig. 4. REAR VIEW.

Weissenborn's "American Locomotive Engineering."

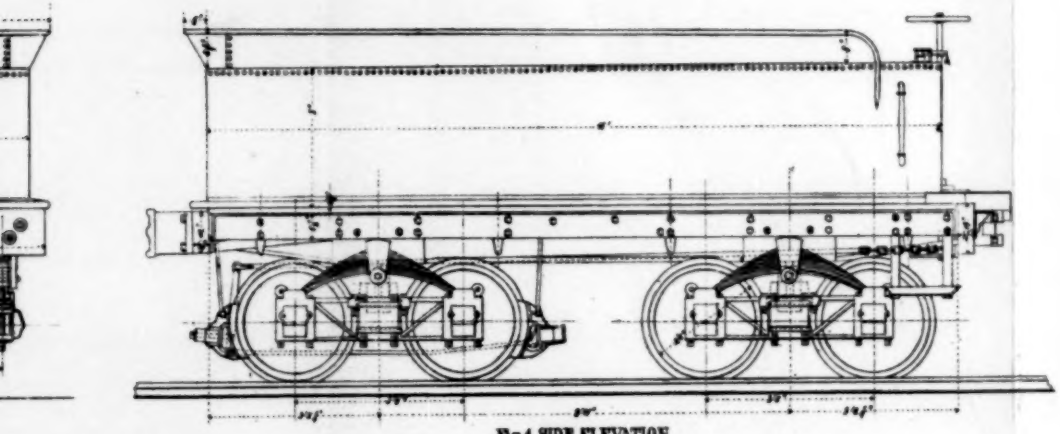

Fig 1. SIDE ELEVATION.

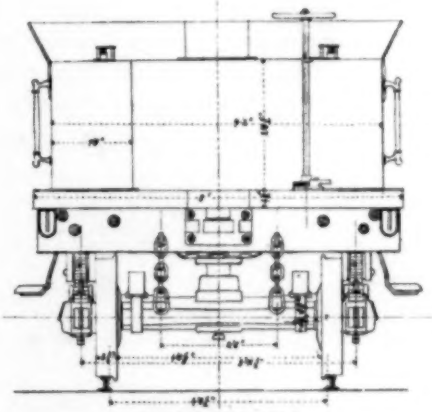

Fig. 2. FRONT VIEW.

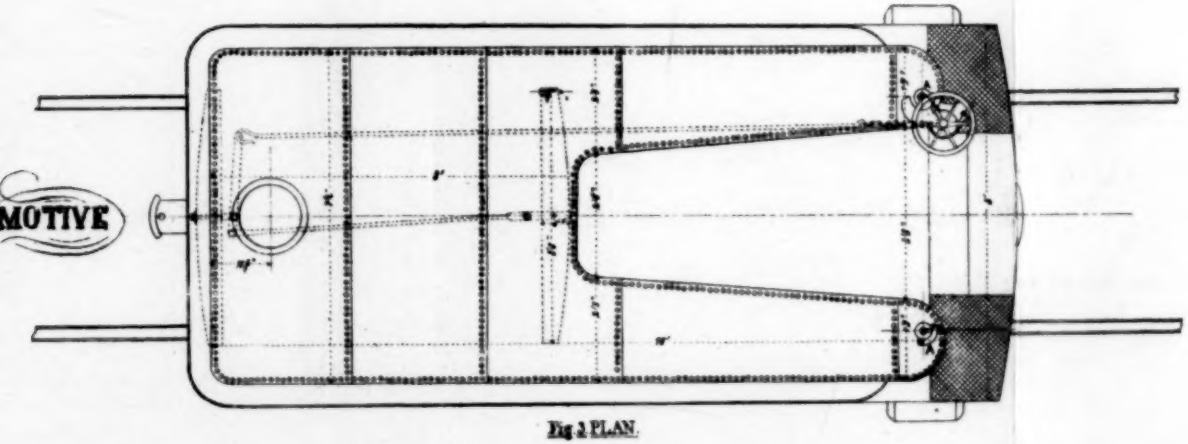

Fig 3 PLAN.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[1]

By Dr. A. W. Hofmann.

From the *Chemical News.*

[Continued from Vol. ciii, page 216.]

Hitherto horse or cart galleries have only been introduced in four solfares, those of Montagna Vecchia (Province of Aragona), San Giovanello, and Montelonge (Province Casteltermini), and Galleria Ercole (Province Sommatino). According to statistical returns collected in 1865 this system has shown very favorable results.

The first attempts at raising the ore by means of shafts were made at a solfare in the district of Respica (Province Villarosa), and in another on the Colle di Madore (Province of Lercara), by a French mining engineer named De Labretoigne. They were carried on intermittently from 1859 to 1861, but the result was so unsatisfactory that they were given up. In 1865 similar experiments were made at the Solfare of Montedore, but with no better issue; and not until 1868 was the use of shafts seriously taken in hand and successfully carried out. This took place at the Solfare of Grottacalda, at that time under the management of the mining engineer Parodi, from whose report we take this brief extract. Here the shafts proved so advantageous that the same system was soon introduced in the solfares of Floristella, of Gallizzi, and in others of less importance. The new arrangement at Grottacalda cost 78,000 lire; the shaft is 137 metres in depth, and has been in use for raising the ore since 1871. Since 1872 a steam-engine of 40 horse power has been working in the great solfara of Sommatino. At the same time shafts were commenced at the solfaras of Raddassa, Montagna (Province Sommatino), and Trabonella in the neighborhood of Sanatra (Province of Caltanisetta), exclusively destined, however, for the removal of water. In place of the wooden pumps formerly in use, metal pumps have been already introduced, which are managed by workmen named *trombatori.*

If we compare the returns of the year 1867 with those of 1871 very notable progress will be perceived. Whilst at the end of 1867,

[1] "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

13 solfaras only employed 20 steam-engines, with a collective power of 256 horses, in 1872 21 solfaras are working with 400 horse power. In the construction of the engines, which are now built on scientific principles, great improvements have been made.

At the mouth of the sulphur mine, each picconiero with the help of his manuali, throws the ore he has raised into a heap (*catasta*), which is then measured by specially appointed officials (*catastieri dell' amminestrazione*). As a unity of measurement the *cassa* is employed, a vessel of the form of a parallelopipedon which, in different mines, holds from 2·5 to 5 cubic metres.

The extraction of the sulphur in Sicily is almost exclusively effected by fusion. The eliquefaction in small cast-iron apparatus (called *doppioni*, because they are fixed in pairs, retort and receiver) as is customary in some solfaras of the Romagna, or in earthen vessels (*pignatti di argilla*), as described in manuals of chemistry, has never been in use in Sicily. As far back as tradition extends very primitive arrangements have been in use in the island, known as *calcarelle*.

For this purpose round holes were dug in the ground of about 2·5 metres in diameter and 4 decimetres in depth, in the midst of which the *picconieri* piled up the sulphur ores in a high mound—an operation which generally took up two days. This heap was set on fire in the evening, and in the morning of the next day so much liquid sulphur has collected in the outer part of the hole that it can be scooped out and cast into rolls—an operation which lasts till evening, and is resumed on the following day. This process involved little outlay, but the yield was small. Only one-third of the sulphur in the ores was utilized, the remaining two-thirds being diffused in the atmosphere as sulphurous acid, to the annoyance of the inhabitants, and to the serious injury of the adjacent fields.

Since 1850 the eliquation of sulphur in Sicily has been materially improved by the conversion of the *calcurelle* into *calcaroni*. The latter, as the word itself implies, are merely excavations like those described above, but on a much larger scale, and of an improved construction. They are large round cavities of a semicircular or semi-elliptical section, of about 10 metres in diameter and 2·5 metres in depth. They are generally contrived in places where the slope of the ground renders it practicable to arrange a communication from without with the lower part of the calcarone, the bottom of which is made

inclining to this point. This external communication, curiously known as *la morte*, consists in an aperture 1·20 metres high and 25 centimetres broad. Within the *calcarone* is lined with a wall of gypsum, from 4 to 5 decimetres in thickness at the back (*i.e.* the part furthest from the opening), but from 1 to 1·2 metres at the front. The masonry is lined with a smooth layer of gypsum, impenetrable by melted sulphur.

The *calcarone* is charged by workmen known as *riempitori*. The cover, the bottom—which is either the mere ground, or, preferably, a hearth formed of hewn stone—first with a layer of finely ground burnt ore from former operations (*ginese*), upon which follows a stratum of larger lumps of ore (*tozzi*). Upon this foundation the ore is heaped up, care being taken to put the smaller pieces principally on the outside of the heap. At the same time the outer communication is blocked up with a kind of vault (*porte*), which is built up with large blocks of the poorest ore about its internal aperture. As soon as the cavity is filled up to the margin the workmen pile up more ore, forming a mound of the shape of a blunted cone (*colmatura, cucuzzo*), still keeping the larger blocks in the centre, and the smaller about the circumference. By means of the large blocks it is found practicable to leave vertical chimney-like openings in various places, not too far from the margin, and especially at the back of the *calcarone* in order to regulate the draught. The mound is then covered with a stratum of finest powdered ore (*sterro*), over which follows lastly a coating of ground burnt ore (*ginese*) and known as the *shirt* of the heap (*camicia*). Before igniting the *calcarone* the outward aperture is closed with a thin wall of gypsum, in which small holes are left at various heights, and are closed during the combustion with balls of clay. The heap is kindled by means of bundles of straw dipped in sulphur and thrown into the draught flues. After about one hour all apertures are closed, and the mound is left to itself for eight or nine days. Then mingled vapors of water, sulphur and sulphurous acid begin to make their way through the outer coating of the heap, and around the flues their appears a slight sublimate of sulphur. At the same time the barrier of the outward aperture becomes hotter and hotter near the ground, and finally red hot. By opening one of the holes which had been stoppered with clay, it is possible to ascertain whether a sufficient quantity of melted sulphur—*olio* as the workmen call it, has collected at the bottom of the furnace. Now begins the work of the sulphur-casters

(*arditori*); with a pointed iron bar (*spiedo*) they perforate the lower part of the gypsum wall, and collect the melted sulphur in moistened moulds of poplar wood (*gavite*) of the shape of a blunted pyramid. In this manner blocks of from 50 to 60 kilos. (*balate*) are obtained, and are sent to market without further preparation. The tapping and casting the sulphur are not everywhere conducted in the same manner. In some works the sulphur is allowed to collect till the end of the entire combustion, and run off at once, but generally the *calcarone* is tapped twice or thrice in the course of 24 hours, so as to remove the sulphur as it collects. The *calcarone* is emptied and prepared for a fresh charge by workmen known as *scalcaratori*.

The duration of the process, from the commencement of charging till the last roll of sulphur has been cast, varies with the capacity of the furnace, the nature of the ore, and the condition of the atmosphere. In furnaces of equal size the operation is the more prolonged the denser the ore and the colder the weather. Wind promotes whilst rain retards the combustion. On an average we may assume that the melting requires, for furnaces containing:—

50 to 60 cassas, . . .	30 to 35 days.
200 " 250 " . . .	50 " 60 "
400 " 500 " . . .	80 " 90 "

Both in the calcarone and in the calcarella a part of the sulphur is burned, in order to furnish the heat required for the fusion of the rest. The consumption of sulphur for this purpose fluctuates greatly and depends on very various conditions. It is particularly large if the ore is very gypsiferous and contains, consequently, much water, or if it has been placed in the furnace when moist, or if violent rains have fallen during the burning. In long continued rains an operation sometimes miscarries entirely. In a successful operation with an ore containing 25 per cent. of sulphur, 70 per cent. of marly limestone, and 5 of water, theoretically, the combustion of $\frac{1}{3}$ of the sulphur should be sufficient, but in practice $\frac{1}{3}$ and even $\frac{2}{3}$ are consumed.

It need scarcely be mentioned that methods have been proposed to obviate this loss, and especially to protect the neighboring population against the pernicious influence of an atmosphere polluted with sulphurous acid.

At Lercara, where, for a length of time, very rich ores (*talamone*) were exclusively obtained very friable, and, therefore, unsuitable for burning in calcaroni, the fusion has long been conducted in open cast-iron pans, of semicircular section, heated by means of vegetable fuel. The expense of melting amounted to 2·50 lire per 100 kilos. In each operation 8 to 9 quintals of sulphur were obtained, and 2 to 3 quintals of fuel consumed. The pans served from four to five years. At the sulphur mines of Madora (Province Lercara), where very poor ores are worked, this method is not applicable. Durand introduced there the furnace bearing his name. It consists of a quadrangular chamber of masonry, each side measuring 2 metres, with a sloping bottom and a vaulted roof, in the midst of which is an opening for charging and emptying the furnace. In the lower part of the front wall is the tap hole, and in each side is an aperture, the one to kindle the furnace and the other to remove the products of combustion. In such a furnace containing 1½ cassas, a fusion (including the time for charging and emptying) lasts twenty-four hours. The process is otherwise conducted as in the calcarone.

Another furnace was built in 1861 by Conrad Hirzel, at the Solfara Col di Serio, in the province of Lercara. By means of this apparatus, which was patented by the inventor, the fusion is effected more rapidly, and every loss, whether by sublimation or by combustion of the mineral, is said to be avoided. But this arrangement, though ingenious, is complicated, and the result has generally not come up to expectation, so that after two years the furnace has been abandoned. An apparatus introduced almost simultaneously by Joseph Gill, at the Solfara della Croce (Lercara), which was to effect the fusion of the sulphur by means of hot air deprived of oxygen, as also the system devised by Heinrich Keyser, for extracting the sulphur by sublimation in cast-iron or earthen retorts, have met with no better fate. The latter process seems at the best merely serviceable for the treatment of very rich powdered ore (*sterri*), and only for the manufacture of flowers of sulphur.

The proposal of H. Condy Bell (1867), to extract the ores in the moist way with the bisulphide of carbon has not been successful. According to experiments made in 1868 at Bagnoli, near Naples, insurmountable difficulties were met with in the attempt to carry out the process on the large scale.

We must also mention the attempts at extracting the sulphur by means of high-pressure steam. The suggestion was made many years ago by Joseph Gill, but experiments on the large scale were first undertaken by Thomas at Palermo, in 1868. The process has been patented by a company, the *Societa privelegiata per la fusione dello solfo, in Italia.*[1] The process requires the use of ordinary fuel. Steam is used at a tension corresponding to the melting point of sulphur. Theoretically a pressure of 2 atmospheres should suffice; practically from 3 to 3½ atmospheres are required. A higher pressure would impair the quality of the sulphur.

Not more than 6 or 7 fusions daily can be effected by means of this system, 2 tons being treated each time. In a successful operation not more than 5 per cent. of the sulphur originally present remains in the residue, so that an ore of 22 per cent. on fusion in steam yields 21 per cent., whilst the process in the calcarone yields merely 15 per cent. This increased production approximately covers the working expenses. Still it must be remembered that Sicily possesses no fuel, and that 60 *lire* is no unusual price for a ton of imported coal. The metal apparatus required is also expensive, not to mention the outlay for the importation of machinery. For the present it must remain undecided whether the steam fusion process is calculated to supersede the old method. For the treatment of very poor ores the former seems already more advantageous. The company above mentioned have undertaken the fusion of the ores on their own account, taking as payment a percentage of the yield, whilst the rest remains the property of the mine owner. This percentage varies according to the nature of the ore; at della Croce it is 32 per cent., but in Madore, Montedoro, and Sommatino only 29.

It must not be forgotten that on account of the different nature of the material operated on, the results in different mines vary greatly. Hence in some places where the new process had been introduced it has been again abandoned, whilst in others its retention is still doubtful.

The purification of sulphur is still principally carried on in France, especially in the neighborhood of Marseilles. In Sicily there are only two or three refineries (at Catania and Porto Empedocle), which only work at intervals and on a small scale.

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[1] Compare also the essay on the utilization of alkali waste (regeneration of the sulphur) in a subsequent portion of this report.

Manufacture of Sulphuric Acid.

By Robert Hasenclever, Manager of the Stolberg Works.

In few branches of chemical technology is it possible to show an amount of progress equal to what has taken place in the manufacture of sulphuric acid during the last ten years. On the one hand, the production has been greatly augmented in consequence of the increased manufacture of soda, potash, by the preparation of artificial alizarin, nitro-glycerine, etc. On the other hand, the process of the manufacture of sulphuric acid has undergone essential alterations.

Whilst former investigations were chiefly undertaken in the hope of discovering new methods of procedure and new apparatus for the manufacture of sulphuric acid, attention has latterly been merely directed towards the discovery of new sources of sulphurous acid, of improved kilns, and of a theoretical elucidation of the process in the lead chambers—in use now for a century—with a view to its practical improvement.

Besides the memoirs of various chemists and technologists in the scientific journals the following works on the manufacture of sulphuric acid have appeared:—

1. M. J. Kolb, "Etude sur la Fabrication de l'acide Sulfurique Considerée au point de vue Theorique et Technologique." Lille, 1865. (Study on the manufacture of sulphuric acid considered from a theoretical and technological point of view.)

2. Dr. C. A. Winkler, "Untersuchungen über die Chemischen Vorgänge in den Gay-Lussac'schen Condensationsapparaten der Scwefelsäure-Fabriken." Freiburg, 1867. (Researches on the chemical processes in the Gay-Lussac columns in sulphuric acid works.)

3. "Handbuch der Chemischen Technologie. Herausgegeben von P. A. Bolley, band ii, 1. gruppe, von Dr. P. Schwarzenberg." Braunschweig, 1869. (Handbook of technological chemistry, edited by P. A. Bolley, vol. ii, group 1, by Dr. P. Schwarzenberg.)

4. F. Bode, "Beiträge zur Theorie und Praxis der Schwefelsäure-Fabrikation." Berlin, 1872. (Contributions to the theory and practice of the manufacture of sulphuric acid.)

5. Henry Arthur Smith, "The Chemistry of the Sulphuric Acid Manufacture." London, 1873. (A German version by Fr. Bode, appeared at Freiburg, 1874.)

6. Lorenzo Parodi, "Sull' Estrazione Dello Solfo in Sicilia, e Sugli Usi Industriali del Medesimo." Firenze, 1873. (On the extraction of sulphur in Sicily, and on its industrial uses.)

The number of the compounds of sulphur applicable in the manufacture of sulphuric acid has considerably increased in the last ten years. Sulphur is only used in a few establishments; the chief material being iron pyrites, and in certain cases galena, sulphuret of copper, copper pyrites, blende, and Laming's mass.

Concerning new arrangements of the sulphur kilns nothing has been published. We must remark, however, that in certain works the pyrites furnaces have been converted into sulphur burners by the simple substitution of plates of cast iron for the grate bars in consequence of the high price of pyrites in the years 1871—1873. Heidenreich, of Hanover, first converted his furnaces in the manner above mentioned, and burnt in twenty-four hours 120 kilos. of sulphur per square metre.

In Stettin, Hamburg, and other places, sulphuric acid has been latterly made from sulphur in place of pyrites. But with the fall in the price of the latter the use of sulphur has again been abandoned.

The export of sulphur from Sicily has latterly reached the figures given in the subjoined table:—

1862	143,323	tons.
1863	147,035	"
1864	139,841	"
1865	138,232	"
1866	179,110	"
1867	192,320	"
1868	172,387	"
1869	170,141	"
1870	172,751	"
1871	171,236	"

For many years sulphur has been largely used in the vineyards of France, Italy and Spain as a remedy for the grape disease. The increased production of gunpowder and ultramarine requires likewise great quantities of sulphur, so that the decreased consumption of sulphur due to the use of pyrites in the manufacture of sulphuric acid has scarcely depressed the exportation from Sicily.

Roasting Pyrites.—The application of iron pyrites for the manufacture of sulphuric acid is now almost universal, and the extraction of this mineral has greatly increased in the last ten years. The

largest quantity is consumed in England, and comes from Spain, Portugal, and Norway. The imports of iron pyrites and Sulphur into Great Britain amounted in tons to:—

	Pyrites from—								Sulphur from
Date.	Norway.	Germany.	Belgium.	Portugal.	Spain.	Italy.	Sundry Places.	Sum Total.	Sicily.
1862	4,975	6,817	9,860	53,296	33,717	——	2187	110,852	54,200
1863	6,736	15,409	12,059	109,180	33,213	——	2628	179,225	43 060
1864	16,087	12,751	7,069	118,489	15,529	——	1065	170,990	40,420
1865	22,229	14,727	2,121	137,787	16,393	——	369	193,626	49,840
1866	38,262	21,574	4,006	165,993	11,910	——	1625	244,596	62,850
1867	77,895	34,592	2,299	105,556	50,222	——	2134	272,698	59.270
1868	63,007	41,559	——	75,883	47,458	794	1019	229,720	64,080
1869	63,091	13,983	——	140,805	99,648	——	2420	319,947	51,580
1870	67,464	14,914	——	174,459	150,996	——	3676	411,512	54,120
1871	74,416	12,809	——	120,573	242,163	——	4581	454,542	——
1872	71,665	5,682	——	180,329	257,429	——	2521	517,626	——

France derives its supply of pyrites chiefly from Chessy and Saint Bel, near Lyons; in the north, Belgian ores are used in small quantities. The pyrites consumed in Germany are chiefly produced from the "Sicilia" and "Siegena" mines, near Siegen; certain Rhenish mines produce also small quantities, such as the deposit of fine pyrites at Schwelm, Rammelsberg in the Harz district, etc.

The production of pyrites (in tons) in the following mines, amounted to:—

	Belgium	Chessy and Saint Bel, near Lyons.	Goslar.	Siegen.	Total Prussian mines except Siegen & Goslar.
1862	——	45,973	——	14,850	7461
1863	36,244	59,699	——	28,765	5934
1864	29,956	61,103	——	29,115	3437
1865	31,818	63,538	——	34,060	4187
1866	55,004	65,222	——	50,875	4302
1867	41,298	75,653	1599	71,835	4756
1868	37,933	75,656	2635	90,100	3953
1869	31,670	91,020	2689	64,789	6394
1870	28,665	63,464	3225	92,048	3191
1871	42.272	68,797	3324	110,432	4574
1872	40,932	99,000	3640	144,745	964
1873	——	127,000	1217	123,172	3748

The furnaces used in roasting iron pyrites vary according as they are intended for lumps, coarse, or small. The burners for lumps agree generally in the point that the ore is roasted on iron grate bars. The kilns employed in England have been repeatedly described—recently by H. A. Smith—and illustrated by diagrams. The indi-

vidual furnaces are separated from each other by small vaults, and are connected in such a manner that the gases escaping into the lead chambers may have an approximately constant amount of sulphurous acid. Each compartment is closed below by a separate door, at which the spent ores are removed. These doors are closed when a fresh charge of pyrites is introduced into the kiln from above, whereby the escape of any considerable quantity of sulphurous acid during the opening of the upper door is prevented. If the difference of level between the kiln and the flue leading the gases into the chamber is considerable, air is drawn in and no sulphurous acid can escape on opening the working door.

(To be continued.)

INVENTIONS OF THE CENTURY.

[Abstract of the first lecture in Prof. Pliny E. Chase's course, on "Lessons of the Centennial," delivered before the Franklin Institute, March 6th, 1877.]

You will not expect me to rehearse in three lectures any considerable portion of the lessons which could be learned by six months' study of the great Exhibition; but you may, perhaps, be interested in briefly reviewing a few of its most obvious teachings. I will ask you to-night to go back, in imagination, to the "good old times" of our grandfathers and great-grandfathers; to the generation which rejoiced in the enterprise of Franklin, who, as Deputy Postmaster General, had established a fast mail line, enabling a merchant or a stock broker or a lover, in Philadelphia, to send a letter to New York and get an answer in a week. There were no friction matches then. Man, as a cooking animal, had so far advanced from savagery as to substitute the flint and steel and tinder-box for the friction of two pieces of dry wood, as a means of procuring the fire that he needed. Matches, dipped in sulphur, served to start a flame from the tinder spark.

The German chemist, Döbereiner, found that platinum sponge *occludes*, or shuts up, many times its own volume of hydrogen. The rapid vibration of the gaseous particles being thus greatly concentrated, the frequent collisions raise the platinum to a glowing heat,

which inflames the gas that surrounds or plays upon it. This discovery led to the invention of his chemical lamp, which is still an interesting toy for the laboratory or study, but not fitted for general use. It furnished, however, an admirable illustration of the great principle of vibration, to which modern research points as the probable origin of all forms of force and motion.

The first chemical matches were often sold at from six to ten cents apiece. They were tipped with a mixture of chlorate of potash and sugar, or some other substance rich in carbon, and accompanied by a vial of sulphuric acid. When the match was dipped into the acid it took fire. Amorphous phosphorus was afterwards substituted for the acid, thus furnishing substantially the same combination that is used in the modern safety match. In 1829, John Walker, a chemist of Stockton-upon-Tees, dispensed with the bottle by including phosphorus in the mixture for the tips, and igniting the match by the friction of sand paper. This was the "lucifer" match, which interested Faraday so much that he sought to confer a great public benefit by promoting its introduction into general use. The various forms of friction match, with which we are all familiar, are merely modifications of Walker's lucifer. Coston's telegraphic night signals, which were in the Centennial Exhibition, are fired on the same principle.

A century ago, the oil lamp and the tallow dip, the latter being by far the more common of the two, helped to make darkness visible. In 1786, the Scottish lord, Dundonald, distilled coal and constructed an apparatus, merely as a curiosity, for burning the escaping gas. His canny workmen used the waste gas for light. In 1792, Murdoch began his attempts to introduce gas for lighting factories, but for several years his efforts met with little success. Westminster bridge was first lighted with gas in 1813, and the neighboring streets in 1814.

In 1790, there were but twenty-five post offices in the United States. Even so lately as in 1836, the postage on a single half-ounce letter was twenty-five cents for four hundred miles or over. Electricity was not impressed into the postal service, by Prof. Morse, until 1843. Prof. Henry's discoveries, which rendered practical telegraphy possible, began in 1830. The first efficient submarine link in Puck's "girdle round the earth," was laid in 1851, between Dover and Calais; the first Atlantic cable, in 1858. Now, through the judicious study of the effects of combined and superposed vibrations, we

have the duplex and quadruplex telegraph, and the telephones of Gray and Bell. There is good reason to believe that the telephones may be so perfected as to enable us, without limit of distance, to send an indefinite number of messages, at the same time and in opposite directions, over a single wire. Already, conversation has been carried on through a wire of over one hundred and fifty miles, so that the words were distinctly audible, and the voices of different speakers were readily recognized. Music has been transmitted from Chicago to Detroit, a distance of two hundred and eighty-four miles, the notes being as clear and distinct at the end as at the beginning of their telegraphic journey.

The granaries of the world are largely supplied by the crops of our teeming western prairies. The "staff of life" is cheapened by the improved drills, ploughs, cultivators, mowers, reapers and threshers, which enable our farmers to cultivate their immense fields and gather their bounteous harvests. The wooden plough, in the Tunisian department of the Exhibition, was nearly as efficient as the one which was used by our great-grandfathers; the present "header," for gathering clover seed, contains the only contrivance which they knew for rapid reaping. The header is, substantially, the same as the machine which was used by the Gauls, in the first century of the Christian era, having a comb in front to strip off the ears of wheat, and pushed by an ox. It received no material improvement until Ogle invented the reciprocating knife, in 1822. McCormick's reaper was not patented until 1834.

Our great-grandfathers rejoiced in leather aprons and homespun dresses. The hand-loom was a familiar household implement; the setting of hand cards enabled farmers' children to earn many an honest penny during the long, but cheerful, winter evenings that they spent in the chimney corner. Hargreaves patented his spinning jenny in 1770; Arkwright's contested patents, which enabled one man with a machine to do as much work as one hundred and thirty men could do by manual labor, were not sustained until 1785. It would require 40,000,000 laborers to do the spinning which is now done in England by machinery alone.

Samuel Slater, who was apprenticed at the age of 14 to Jedediah Strutt, Arkwright's partner, made such improvements that he was entrusted, before he came of age, with the supervision of a new mill and the construction of its machinery. Almy & Brown were then

about erecting a factory at Pawtucket, in which they offered Slater an interest. He accepted the offer, but the rigid British laws, against the emigration of artisans, prevented his taking any machinery or drawings with him. But his capacious head held all that he needed, and in 1790 he started the first successful cotton mill in the United States.

While constructing his machinery, Slater wished to obtain twilled cards of a pattern that had never been made in America. Pliny Earle, who agreed to make them, used two needles inserted in a bit of wood, to prick the holes in the leather into which the carding teeth were to be set. The tediousness of the operation led him to the invention of a machine which is still in use, and which, while it performed the work more satisfactorily, saved the labor of sixty men.

In order to prepare the cotton for carding, it was necessary to separate the fibre from the seed, a tedious process, especially with green seed cotton, which was the best variety. The cleaning of a single pound was considered a good day's work for a negro. This labor, added to the costs of cultivation, transportation, manufacture, reshipment, commissions and mercantile profits, made even the coarsest cotton goods expensive. Whitney's cotton gin, which was completed in 1793, raised the value of the cotton plantations, from fifty to one hundred per cent. Judge Johnson said, "If we should assert that the benefits of this invention exceed one hundred millions of dollars, we can prove the assertion by correct calculation." All the emolument Whitney received for this immense benefaction, was $50,000 from the state of South Carolina, a tax of two shillings and six pence levied for five years upon every saw used in North Carolina for ginning cotton, less the collection expenses, and some *promises*, which were never fulfilled, from other states. A large portion of the money which was thus obtained, the inventor was obliged to spend in vexatious lawsuits.

The increasing demand for machine cards, consequent on the reductions in the cost of cotton goods, stimulated mechanical ingenuity to devise means for their more rapid production. Eleazar Smith invented a machine which would pierce the leather, cut the wire, bend it into proper shape, or both bend and set it, provided the tooth was straight. But, in order to furnish the requisite resistance in the carding process, it was necessary that the tooth should be so bent as to form a knee; and after numerous vain attempts to set a bent

tooth, Smith abandoned his undertaking. Amos Whittemore had been experimenting in the same direction, and hearing of Smith's machine, he asked if he would sell it. A price being soon agreed upon, Whittemore took his purchase home, and the thought is said to have come to him, in a dream, that it would be just as well to bend the tooth after it was set, as to set it after it was bent. He accordingly added a simple bending die, took out a patent, and sold the right for $150,000. It was afterwards re-purchased by his brother Samuel.

The rapid increase in the production of plain fabrics, consequent upon these inventions, was accompanied by improvements no less wonderful in the weaving of ornamental designs. The warp threads were at first moved by treadles, the design being limited by the number of treadles that one man could work. "Draw-boys" were next introduced, who operated design cords which were fastened to the side of the loom; but the constrained position that they were obliged to keep, ruined their health in a few years. Vaucanson introduced tambour machines, which were subsequently improved and finally perfected by Joseph Marie Jacquard, who reduced the roller to eight sides, which carried an endless chain of cards, pierced with holes so arranged as to allow the passage, at the proper moments, of wires connected with the warp threads. The Lyons silk manufacturers wove a portrait of Jacquard in his workshop, which required 24,000 cards, each card being large enough to receive 1000 holes.

William H. Horstmann first introduced the Jacquard loom in America, in 1824. In 1837-8, his son, William J. Horstmann, manufactured power looms of his own designing, and employed them for weaving narrow textile fabrics. The complication, delicacy and accuracy with which the mechanical fingers and scissors and plyers of the card-setting and ornamental-weaving machines do their appointed work, entitle them to rank among the most wonderful triumphs of human skill and creative genius.

In order that the products of the loom may find a ready market, it is desirable that they shall be clean, and that their colors shall be "fast." Both of these ends are secured by the use of a very cheap soap, of which there are specimens on the table. You see that it is a very hard soap when in its most compact form, and that it looks very much like bottle glass. It is at once a glass, and a salt, and a soap, being the silicate of soda, or soluble glass. If it is allowed to run from the furnace into water, it crumbles into a coarse powder,

which can be dissolved in boiling water, forming a soapy solution, which may be used for washing, for taking the place of resin in common soap, for forming artificial stone, for fireproofing garments or scenery, for a mordant in fixing dyes, for lining coal oil barrels to prevent leakage, and for various other purposes.

Fibres may be felted, as well as woven. The true felting process, which you can see in any factory where wool hat-bodies are made, requires animal wool or hair. You may learn why the animal fibres tend to cling together, by working a hair lengthwise through your fingers. You can readily move it in one direction but not in the other. This is due to little protuberances on the surface of each hair, all pointing in one direction, and the interlocking of those protuberances gives considerable strength to the bocking or other felted product.

Paper is a sort of felt, but the adhesion of its fibres is mainly due to a kind of paste. The "mammoth ream," with material sufficient for 500,000 sheets of note paper, and the general American display of paper, in all the principal styles of manufacture, attracted great attention from the foreign visitors to the Exhibition. The parchment papers, suited for bookbinding—the paper imitations of silk and leather, for hangings and other purposes—the great variety of applications of papier-mâché and carton-pierre, the "matrix" for stereotyping any required number of duplicate forms to be used in printing newspapers—represent only a few of the late inventions in this single line of manufacturing industries. By means of the continuous rolls, the cutters, the cylinders, the flexible matrices, and the webs, the clumsy and tedious processes of forty years ago have given place to fast presses that are capable of printing a mile of newspapers per minute, throwing off the printed and folded sheets as fast as two active boys can carry them away.

Those of you who have read Gulliver's travels, will remember that the philosophers of Laputa were represented as engaged in endeavors to extract sunbeams from cucumbers. Can you imagine any idea more absurd? Can you not picture to yourselves the smile of satisfaction that lighted Swift's face, as he penned the keen sarcasm on the philosophical speculations of his day? Yet in science, as in religion, we may often apply the maxim, "*credo quia impossibile est*"—its very impossibility makes it credible. The Laputan dream has been literally fulfilled; for if you gather a cucumber that has been

exposed to the strong sunlight, take it into a dark room, wrap it in paper that has been prepared for photography, and shield it in all possible ways from external light, the delicate vibrations which have been absorbed will again be given forth, imprinting a distinct image of the cucumber on its sensitive wrapper. In connection with this fact it may be well to remind you that, although Davy and Niepce had developed camera pictures, and Daguerre had made them permanent, the limning sun took its first portraits in America.

Such are a few of the inventions which have contributed to the marvelous physical progress of the past century. From the many others I will select but one; the one which is, in many respects, the most important of all: the steam engine. Hero, of Alexandria, invented the eolipyle, which remained, for ages, an unsuggestive toy; the Marquis of Worcester described forms of apparatus by which steam could be applied to useful work; Savary, Newcomen and Crawley made pumping engines for the drainage of wells and mines; but it was left for the ingenuity of Watt, by a series of improvements which were completed in the year of our national birth, to give us that mighty instrument of unwearying and unlimited toil which has wrought a revolution in our homes, in our workshops, on our farms, on our highways, in the bowels of the earth, and on the face of the mighty deep. Steam was first applied to cotton machinery by Arkwright, in 1785; to sawing stone and grinding plaster, by Oliver Evans, in Philadelphia, about the same time; to a boat on the Forth and Clyde canal, by Symington, in 1802; to river navigation, by Fitch, Stevens, Evans and Fulton, between 1804 and 1807; to a road engine or locomotive, in 1805. Stephenson's "Rocket" first drew a train of cars at the opening of the Liverpool and Manchester Railway, in 1829. The first century of this mighty monarch's sway has ended, and through its instrumentality the capacities of mechanical industry have been increased more than tenfold. Machinery is now doing more work than the whole population of the globe. The beautiful engine in Machinery Hall, which accomplished, so easily and so quietly, a task such as had never before been witnessed, may therefore be fitly remembered as the centre of our exhibition, which worthily and suggestively exemplified "the inventions of the century."

[The lecture was copiously illustrated by experiments, specimens of materials and fabrics, and lantern pictures.]

THE METALLURGY AND ASSAYING OF THE PRECIOUS METALS USED IN COINAGE.[1]

[Abstract of the first of a course of two lectures, delivered before the members of the Franklin Institute.]

By ALEXANDER E. OUTERBRIDGE, JR., Assay Department, U. S. Mint, Philadelphia.

ON GOLD.

The book of nature is a vast volume, from any part of which we may obtain wonderful sources of instruction and entertainment. Whether we contemplate the immensity of the vault of heaven with its innumerable suns revolving in their orbits, or whether we examine the tiniest blade of grass or the sting of the smallest bee, we find equally interesting subjects for study. It is one chapter, nay, rather one small page, of this great book, which I propose to open for you this evening, and my subject possesses one material advantage in its novelty in a lecture course.

The history of the precious metal which we call gold, carries us far back to the first records of the civilization of the human race. There is every probability that gold was the first metal known to man. Centuries before its use as a medium of exchange or unit of value, it was known and highly prized as an article of ornament. The ancient symbol of gold among the Egyptians was a circle, which typified to their minds the idea of perfection and divinity.

In the Old Testament we find very frequent mention of gold, and the vast amounts of precious metal used by King Solomon in the adornment of the Royal Palace and the Holy Temple excite our wonder and admiration.

The marvelous accounts related by the classic writers of the great quantities of gold possessed by the Oriental monarchs of antiquity must, of course, in some cases be accepted *cum grano salis*, and yet the recent archæological and treasure discoveries of General Di-Cessnola, in Cyprus, and of Dr. Schliemann at Mycenæ, are at

[1] As the lectures were not delivered from manuscript, this abstract for the JOURNAL has been prepared from memory, assisted by brief notes of headings. It has been found necessary, on account of limited space, to omit some portions, and to curtail others.

least partial confirmations of the stories related by Herodotus, Pliny, Homer, and other ancient authors. The beautiful collection of Etruscan and Phœnician golden ornaments—amulets, rings, fibulæ, etc., exhibited in the Castellani collection at the Centennial Exhibition, is a proof of the antiquity of the art of refining gold and working it into artistic forms of great beauty. Indeed the method of joining microscopical particles of gold, forming the ornamentation called "granulated work," is a marvel to modern experts.

I wish you to pause with me for a moment to consider a phase in the history of the precious metals of absorbing interest—I allude to the search for that ever fleeting will-o-the-wisp, the Philosopher's stone. Although we may laugh at the delusions under which the enthusiastic alchemists of the middle ages labored in their search for that *elixir-vitæ* which was to enable them to cure all ills, to prolong life to an indefinite period, and to transmute the precious metals into gold, we must not forget that we owe to their labors many valuable metallurgical discoveries. The older alchemists believed that the great secret was possessed by the Devil and could only be procured at the expense of the soul—while the more modern enthusiasts relied upon earthly means, and they accordingly triturated and boiled together the most heterogeneous compounds. Thus, in an old work, called the "Gold maker's guide," there appears this amusing recipe: "Take of the gall of a black tomcat, killed when the night approacheth, 1 part; of the brains of a night owl taken from out its head when the morning dawneth, 5 parts; mix in the hoof of an ass when the tide turneth; leave it until it doth breed maggots; place it on thy breast-bone when the moon shineth bright—and—thou wilt see a sight which the eye of mortal man ne'er beheld afore." Again, "Hide and couple in a transparent denne, the Eagle and the Lyon, shut the doore close, so that their breath go not out, and strange ayre enter not in; at their meeting the eagle will tear in pieces and devoure the lyon and then be taken with a long sleepe." The explanation of such riddles is simple enough when we have the key; for example, I have in my hand a glass vessel containing gold foil; this is typified by "the lion." I now cast in "the eagle," viz.: a little mercury; the mercury quickly forms an amalgam with the gold and becomes a sluggish or pasty mass, *i. e.* "is taken with a long sleepe."

Numerous guides appeared from time to time, but, unfortunately, those which were written plainly never yielded a stone, while those

written enigmatically could not be understood.[i] This mysterious manner was not always owing to an intention to deceive—many philosophers believed it was wicked to reveal the secrets of nature to the vulgar people, and might even cause the death of the writer.[ii] So strong was the faith in the power of transmuting base metals into gold, that Henry VI of England issued a royal proclamation, in the year 1423, encouraging the art of gold making, in order to obtain means to pay the state debt. Edward IV, in 1476, accorded to a company "a four yeare privilege of making gold from quicksilver.[iii]

Our limited time will merely permit us to glance at these interesting by-paths in the history of the precious metals, and we are now prepared to investigate the

PHYSICAL AND CHEMICAL PROPERTIES OF GOLD.

You are all, doubtless, familiar with the rich orange-yellow color of gold, and yet but few of you have seen the royal metal in a state of purity. In this little porcelain saucer I have fastened with mucilage a number of granulations of chemically-pure gold. This gold is prepared with the most scrupulous care in the Assay Laboratory of the Mint, for test purposes, and is absolutely free from foreign substances.

By the aid of the improved form of megascope, devised by the Secretary of the Institute, Mr. J. B. Knight, I shall project the magnified image of these beautiful granules upon the screen. There, you see, they retain their natural brilliant lustre, golden color and

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[i] In 1649 there appeared, "A master key to the opened heart of fatherly philosophy, and the "Childbed of the philosopher's stone."

In 1700, "Philosophical field sports and nymph catching," and the "Brightly shining sun in the alchemical firmament of the German horizon," "Chymical moonshine," etc., etc.

[ii] Wilhelm von Schrœder, in 1684, wrote a book called "Necessary Instructions in the Art of Gold Making," in which he says: "When philosophers speak openly, a deceit lies behind their words; while when they speak enigmatically, they may be depended upon."

[iii] The Danish ducats of 1647 were made of gold obtained, as it was believed, from artificial means, by the alchemist of Christian IV, named Caspar Harbach. So under the Emperor Ferdinand III, in 1648, a large medal was struck from artificially-prepared gold. In like manner the ducats struck under Landgrave Ernest Lewis, of Hesse Darmstadt, were of artificial gold, prepared, it was said, by the transmutation of lead.—*Reducer's Manual.*

appearance of solidity.[1] So much for the color of gold by reflected light. Here is a sheet of gold-leaf, mounted on glass; it is partially transparent, and you might suppose that the transmitted light would also have the same orange-yellow color; let us see. I place the leaf in the oxy-hydrogen lantern, and the disc of light upon the screen is tinged a decided *bluish green*. This property of reflecting one color and transmitting another, is peculiar to gold. We are thus led, by a natural association of ideas, to the question, how thin is this sheet of gold-leaf?

The wonderful malleability and ductility of gold was a property well known to the ancients. Homer speaks of the art of gold beating, and Pliny mentions that an ounce of gold was beaten into 750 leaves, each leaf being about four fingers square. Gold leaves of extraordinary thinness have been found on the coffins of the Theban mummies. The rude specimens of gilding on the walls of the Peruvian temples, and the palace of Tippo-Sahib at Bungalore, prove its extensive application in ancient times. We also have biblical authority to the same effect.

Experiments made in modern times have shown that a grain of gold can be beaten out so as to cover a space of 75 square inches, having a thickness or rather thinness of $\frac{1}{367650}$ part of an inch. While reflecting upon this remarkable fact, the thought suggested itself to me, that the film of metallic gold deposited by means of the galvanic battery must be far thinner. And as the art of gold plating is so extensively applied to a great variety of ornamental metal objects, it seemed an interesting query, how thick a film is required to produce a fine gold color? On inquiring into the subject I did not find that any careful notes had been recorded, and I was led to try some experiments with rather interesting results, although they are not yet finished. Here are two highly burnished plates of metal, looking like pure gold; they have a metallic surface of twenty square inches each; these plates were cut from a strip of copper which I had rolled down to a uniform thickness of $\frac{5}{1000}$ of an inch. They were boiled in alkali to remove grease, and accurately weighed on an assay balance of extreme sensitiveness.

A "gold blush" of sufficient depth to produce this fine gold color was then deposited by the battery; the strips were carefully washed

[1] Several gold coins, medals and ornaments were exhibited, and elicited the applause of the audience, both on account of their inherent beauty and the brilliancy of their reflection.

and dried without rubbing; they were then reweighed, and I found they had gained exactly one-tenth of a grain each. It is thus apparent that one grain of gold would cover a space of 200 square inches, when deposited by the battery, as compared with 75 square inches by beating.

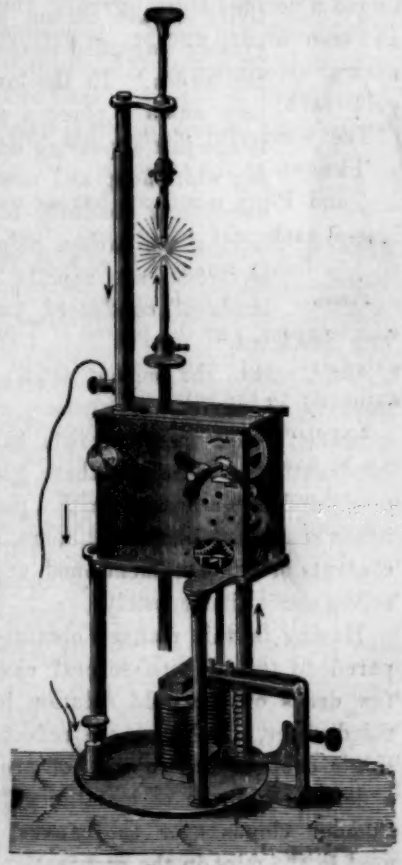
The film of gold appears evenly deposited, under the microscope, and it is more than $2\frac{1}{2}$ times thinner in the former case than in the latter, or $\frac{1}{980400}$ of an inch as compared with $\frac{1}{367650}$ of an inch.[1]

It is stated, that when a cylindrical bar of silver is coated with gold and drawn into the fine wire used in embroidering housings, etc., one grain of gold will cover a length of 345·6 feet of wire.

Gold deserves its name of "noble metal" from its power of resisting the rusting and tarnishing action of the atmosphere, even when subjected to the severest trials. Kunckel kept a mass of gold in a molten state exposed to the atmosphere, for a period of nearly 30 weeks; at the end of that time it had not lost a single grain in weight.

Gold may be melted at a temperature of a little over 2000° F. in a wind furnace.

We may even cause gold to boil and vaporize by means of the intense heat of the electric arc.



Electric Lamp.

Here is an apparatus designed to produce an exceedingly powerful electric current. The copper wires

[1] "A leaf of beaten gold occupies an average thickness of no more than one-fifth to one-eighth part of a single wave of light. By reducing the thickness of the leaf by solution in cyanide of potassium, I think 50 or even 100 might be included in a single progressive undulation of light."—Faraday's Researches on the "Experimental Relations of Gold (and other metals) to Light."—*Philos. Trans.*

conveying the current terminate in two sticks of carbon placed vertically one above the other in the focus of the condensing lens of this large lantern; when the points of carbon are brought in contact they become intensely hot, and on separating the poles, the current is carried across the hiatus, by the conductivity of the carbon particles. The lens projects the greatly magnified image of these incandescent poles upon the screen.[i] In the lower carbon is bored a small cavity into which I place a particle of gold, and you see its image just appearing upon the screen as a globule becoming white hot; ah! now it boils, and there darts forth an exquisitely beautiful tongue-like flame of *vapor of gold*, licking the carbon points, and there, upon the opposite electrode, are rapidly appearing small brightly shining beads of condensed vapor of gold, resembling sparkling dewdrops.[ii]

Carbon Points.

Gold resists the solvent action of nearly all single acids, but a mixture of nitric and muriatic completely dissolves it as a perchloride; hence the alchemists gave the name of *aqua-regia* to this combination. Here are three glass vessels containing sulphuric, nitric and muriatic acids, with a piece of pure gold in each one, where it has remained for several hours, quite unchanged. I now pour the contents of the last mentioned vessels together, and our gold dissolves almost immediately.

Having in this manner obtained a solution of gold, we are prepared to test it with several characteristic re-agents. I place a few drops of the gold solution in this little tank containing distilled water, which you see reflected upon the screen; I now add a single drop of the solution of proto-sulphate of iron, and instantly a dark precipitate of metallic gold in fine division, rolls like angry thunder clouds over the canvas. This method of precipitation is used in the mint in the preparation of chemically-pure gold. I now add, to a fresh solution of gold, a drop of ammonia: a precipitate of

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[i] The cut shows the carbon points inverted, as they appeared on the screen.

[ii] The apparatus used for the development of the electric current was "Wallace's Duplex magneto-electric machine," and was kindly furnished for these lectures by the manufacturers, Messrs. Wallace & Sons of Ansonia, Conn. The shaft was revolved at about 1200 revolutions per minute by a steam engine placed at the back of the stage. The light produced was remarkably steady and intensely brilliant.

a very different character appears upon the screen. This is the substance known as *fulminating gold*, and is a dangerously explosive compound; fatal accidents have occured from its careless or ignorant preparation. Again, I take a fresh solution which is somewhat acid; into the tank, I place a thin strip of tin, it is attacked by the acid; proto-chloride of tin is formed, which instantly unites with the gold, developing very pretty purple streamlets. This is the well known "purple of Cassius," about whose chemical composition there has been a great deal of discussion. The Cassius purple is largely used in the arts, in staining ruby glass, and giving to enamel the delicate rose-pink color.

SOURCES OF GOLD.

To say that gold is at once a *rare* metal, and yet that it is one of the most widely disseminated of the metallic elements, seems at first sight contradictory; and yet it is, in a sense, literally true. Gold is found in Europe, Asia, Africa and America; it was known, in the time of Herodotus, to exist in Russia in the Ural Mountains. The mines were afterwards re-discovered in 1743, during explorations ordered by Peter the Great. The gold and silver mines of Spain have been worked from the most remote periods; both Strabo and Pliny mention the abundance of the precious metals, and it is stated that Hannibal would have been unable to continue the war in Italy but for the discovery of many mines in Carthagena. China and Japan, India, Ceylon, Sumatra, Borneo, the Celebes and Philippine Islands, all add a sheaf to the golden harvest. The mountains and streams of Africa all contain gold. The Transvaal Republic, in Southern Africa, promises vast wealth of native gold to the hardy explorer; some magnificent nuggets were brought to us recently by a prospector from this almost inaccessible region. Some of these nuggets were for a short time placed at the Centennial Exhibition.[1]

It remains for our own country to have the honor of possessing the most extensive gold and silver producing regions of the world at the present day. California and Oregon, Idaho and Washington territories, Nevada and Colorado, Montana, Arizona and New Mex-

[1] A *fac-simile* of one of the largest nuggets ever found in Australia was exhibited to the audience. It was prepared at the Department of mines in Melbourne, and formed an attractive object in the Victorian Court of the late exhibition.

ico, all contribute their quota.[i] Even the Philadelphia bricks, of which our houses are built, contain gold securely locked within their walls, as was proved by the interesting investigations made in the mint some years since.[ii] Here is a speck of gold, barely visible to the naked eye, which was extracted at the assay laboratory from galena of Bucks Co., Pa., representing one part of gold in 6,220,000 parts of ore.

GEOLOGICAL POSITION.

Gold is found in nature in the form of dust, grains, nuggets, and associated with quartz, etc. "It was formerly supposed that productive gold veins were confined to the Silurian rocks, but the discovery of fossils of the Carboniferous period in California by Dr. Trask in 1854, the exploration of Professor Blake, and the subsequent discovery of secondary fossils in the main belt of gold bearing States, together with the discoveries in Hungary in 1861–62, proving that the rocks holding the gold belong to the latest geological periods, even as late as the Tertiary—all show the fallacy of the opinion that productive gold veins are associated chiefly with the older rocks." [iii]

MINTING.

Gold is received at the mint in the form of native grains, dust, amalgam, photographers' waste, old jewelry, dentists' plate, etc., and often contains a great variety of base metals, destroying its ductility, and rendering it totally unfit for coin. It is necessary to eliminate these, and then to effect the removal of silver. We will follow in imagination the course of a deposit, consisting, let us suppose, of old coin and jewelry, as it is received at the mint counter.

The metal is placed in a locked box, and carried to the "deposit

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[i] According to the record of Wells, Fargo & Co., the sole carriers of the gold and silver product of the Pacific States, the total gold product of the mines west of the Missouri River, for the year 1876, was $44,828,501. This exceeds the amount produced in any year since 1870. The highest yearly product was $65,000,000 in 1853. The total gold produced since 1849 is $1,858,400,745. The total stock of gold in the world, at the present time, has been estimated at $5,540,000,000, with an annual loss by wear and tear of $15,000,000. This is interesting, but can hardly be considered more reliable than a guess.

[ii] The report of these experiments, made by Profs. Eckfeldt and DuBois, states that the clay contains about forty cents' worth to the ton; that it is homogeneously diffused; and, from an estimate made of the extent of the clay bed, it was found that more gold lies under the paved portion of the city "than has yet been brought, according to the statistics, from California and Australia."

[iii] Blake's Report on the Precious Metals at the Paris Exposition.

melting room;" here it is melted under a protective covering of borax, and constantly stirred, to render the mass homogeneous. It is then cast into a bar or "shoe" mould, and weighed; this is the weight at which the mint receives the deposit. A small chip is now cut off, for purposes of assay. A rigid analysis is made of this sample, and the result determines the value of the entire mass, by calculation to the fraction of a cent, and the depositor is paid accordingly. As the largest weight used by the assayer is the demigramme (about $7\frac{7}{10}$ grains Troy), and the deposit frequently represents thousands of dollars, it is evident that a very slight error in the assay would amount to a considerable sum total;[1] the assayer accordingly carries his actual analysis to the ten-thousandth degree, viz.: the twentieth part of a milligramme, or the $\frac{1}{1295}$ part of a Troy grain. The fine assay balances will indicate even a smaller weight than this. The assayer rolls the sample into a thin ribbon, for convenience of cutting; the weight of half a gramme of this gold alloy is enclosed in an envelope of pure lead, and melted in the muffle of the assay furnace, in a small cupel made of pressed calcined bones. The lead rapidly oxidizes, and in this condition is much more fluid than the simply melted precious metal; it therefore sinks into the pores of the cupel, carrying with it all the base metals originally combined in the alloy; the button of precious metal remaining is weighed, and the proportion of base metal determined; another weighing of the sample is made as before, to which is added fine silver granulations in the proportion of about two parts of silver to one of gold. The alloy is cupelled as before, and the silvery button remaining is laminated, coiled into a "cornet," and boiled in nitric acid. The acid dissolves all the silver, leaving a roll of pure

Assay Balance.

Muffle.

[1] The average weight of one "melt" of gold ingots for coin, the fineness of which is determined by assaying a slip cut from the first and last ingot cast, is 4000 ounces Troy. The value is about $75,000 in gold. Melts containing as much as 5500 ounces have been made, but it is found very difficult to render the metal homogeneous, owing to the difficulty of pushing the stirrer down to the bottom of the pot.